41-28
410

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. I.—*Review of the Geological Report on the Chippewa Land District of Wisconsin and part of Iowa, made in the year* 1847, *under the direction of D. D. Owen, M.D.*, U. S. Geologist for Wisconsin and Iowa.

IN our last volume we gave a brief notice of a geological survey of the Chippewa Land District of Wisconsin and a part of Iowa; made under instructions from the Secretary of the Treasury of the United States and conducted by Dr. D. D. Owen as principal Geologist aided by Dr. J. G. Norwood as Assistant Geologist, and by the following gentlemen who conducted the operations of the sub-corps: Dr. A. Litton, Dr. B. F. Shumard, Mr. B. C. Macy, Mr. John Evans and Mr. A. Randall.

We propose in the present number to give a further brief review of that report setting forth the general and most important results.

The report now before us contains only an account of the field operations of the U. S. Geological corps engaged in the above district during the summer and autumn of 1847, and is therefore only the commencement of the work continued in 1848 and 1849.

The situation and extent of the country examined is given on page 8 of the report as follows:

"The seat of operations of the party appointed to explore the mineral lands of Wisconsin and a portion of Iowa was, during the summer and autumn of 1847, in a portion of country lying chiefly east of the Upper Mississippi above Lake Pepin, and extending north to Lake Superior. There was, however, also included a portion of Iowa, stretching north from the northern

boundary of the geological survey of 1839, as far as the St. Peter's river; and also a tract of country north of the Wisconsin river. The principal streams which water it are Black river, the Chippewa, and the St. Croix, flowing southerly into the Mississippi; Mauvaise Riviére, (Bad river,) and Bois Brulé, (Burnt Wood river,) falling into Lake Superior; and Turkey river, Upper Iowa, Hokah, Miniska, Wazi Oju, Cannon, Vermillion, and a portion of St. Peter's flowing eastwardly into the Mississippi. It comprehends so much of the Chippewa land district as lies within the boundaries proposed for the State of Wisconsin, the southern part of the country bordering on the Kickapoo, together with the chief part of the Winnebago reserve, the half breed tract and a strip of the Sioux country west of, and adjacent to, the Mississippi, and reaching north to the St. Peter's.

"It lies between 43° and 47° north latitude, and between 89° and 94° of longitude west of Greenwich, and embraces about forty-six thousand square miles of surface."

In addition to the general reconnoissance made of the above region of country, a detailed survey was made of about thirty townships, west of the 4th P. M. on Black river in latitude 44° 30′, and about sixty townships on the St. Croix river in latitude 45°. Nineteen sections have been constructed by Dr. Owen and the other gentlemen of the corps at the most important points on the Mississippi, and six on the St. Croix arranged in such a manner as to form a diagram of comparative heights, not only of the outline of the country, but also of the principal members of the prevailing geological formations. One continuous section extends from the mouth of the Wisconsin, where the survey of 1839 terminated, to the Falls of St. Anthony; one from the Mississippi to the Falls of the St. Croix; one from the mouth of the St. Croix to the Falls of St. Anthony on a more extended scale than that appended to the general Mississippi section; one from Lake Superior to Portage Lake; one from the head waters of Wisconsin river to the Dalles of that river; one from Lake Superior to the Falls of the St. Louis river; one from Lake Superior along the 4th P. M. to Black river, and thence to the Mississippi; one along the correction line from the 4th P. M. to the Mississippi; one from the Kinikinick in a southwest direction across the St. Croix. Also a particular section at the Falls of St. Anthony. Diagrams of summit levels show the relative elevation of ground between the Mississippi and Lake Superior in three different directions.

Several of the above sections are so contrived with landscape back ground, as to present not only the natural exposure of rock, but also the general outline and appearance of the country through which the sections run.

The report is also illustrated by a *provisional* geological chart showing the approximate boundaries of formations; and by twenty-three sketches exhibiting the geological features of the landscape.

The geology of the district is described under the following heads:

1. Formations of the Upper Mississippi.
2. Formations of Red Cedar river and the Winnebago reserve.
3. Formations of the interior of the Chippewa Land District.
4. Formations of Lake Superior.
5. Drift.

In our notice of these topics we must necessarily confine ourselves to leading results.

It appears that the Upper Mississippi country north of the Wisconsin river to within a short distance of the mouth of the St. Peter's, is based on the magnesian limestones and sandstones older than the lowest of the formations of the valley of the Ohio; a portion of them being cotemporaneous with the calciferous group and Potsdam sandstone of the New York survey.

The portion of the report relating to these formations, which will be read with peculiar interest, is that which relates to the fossiliferous beds of these formations, since hitherto they have been regarded as almost barren of organic relics.

The results of this survey seem to show that it is to this portion of the United States that we must look to throw most light on the earliest organic forms.

On this subject we find on page 14 the following paragraph:

"If we except the white sandstone the terminating mass of F. 1 e,* the one upon which the lower† magnesian limestone (F. 2) rests, nothing definite was known up to the period of the present survey, of the nature or character of the underlying beds just described. Neither had any well defined organic remains been described anywhere beneath the grey and blue fossiliferous beds which form the upper portion of the sections at Prairie du Chien; so that there was an entire absence of all palæontological evidence as to the exact place which these strata occupied in the geological series. It is, therefore, with no small degree of satisfaction that I find myself able, from the observations of last summer, to disclose a new feature in the palæontology of Western America, and thus to furnish, not only to the geologist, a key to the stratigraphical position of the rocks north of the Wisconsin river, but, at the same time, to the miner his surest and safest guide by which to direct operations in the search after mineral wealth.

---

* The lowest bed at the mouth of the Wisconsin river.

† In contradistinction to the upper magnesian limestone, the lead bearing rock of the Mineral Point District. Se report of 1839.

"More than one half of the above series, supposed at first to be quite barren of all organic forms, has already been proved fossiliferous, and subsequent search will no doubt develop others.

"It is, moreover, worthy of remark that the most fossiliferous portion of F. 1 is not its upper part, but beds which lie quite low down, even seven to eight hundred feet beneath what was, up to this time, considered the limit of the fossiliferous strata of the Mississippi valley. Yet these strata prove to be as densely crowded with organic relics as any of the most fossiliferous strata of the blue limestone of Ohio, Indiana, and Kentucky. The proportion of genera and species, it is true, is not great, but the number of individuals is immense; some slabs are so covered with shells, that it would be difficult to place the finger on a spot without touching some of them. The prevalent genera are *Lingulas* and *Orbiculas;* yet associated with these are some remarkable forms of crustaceans. The specimen figured on Pl. 7, fig. 1, is the pygidium of a peculiar trilobite, armed with spinous processes projecting from its posterior margin. I obtained it in thin bedded silico-calcareous layers near the level of low water mark below Mountain Island, in connection with schistose gritstones. The latter are charged with very perfect specimens of a small fossil shell having a nacreous lustre closely allied to *Obolus Apollinis* of Eichwald, which are found by thousands in the inferior sandstones of the protozoic strata of Russia. Associated with these shells are also found remarkable compressed sub-conical bodies, the nature of which I have not fully determined; but they are, perhaps, spines of much larger trilobites than the one represented on Pl. 7, F. 1. Yet these beds are identical with layers near low water at Mountain Island, entirely beneath a Lingula sandstone which, in all probability, is the western equivalent of the Lingula beds of the New York Potsdam sandstone, considered by most American geologists the oldest fossiliferous rock in the United States. The imbedded species of each seem the same, as far as one can judge from mere casts. At a little higher geological level, between Prairie a la Crosse and Bad Axe, I obtained numerous casts of Orthis in an impure, dark, flesh-colored, calcareous rock, associated with bucklers of a species of trilobite, which appears to be new. In a similar rock, near the foot of La Grange mountain, I also observed casts of Delthyris beneath green sandstone. (F. 1 c.)

"About the same geological horizon, in an argillo-calcareous rock, near the level of the head of Lake St. Croix, is a very large species of *Asaphus*, the buckler and post-abdomen of which is figured on Pl. 7, Fig. 2 and 3. Finally, at Marine Mills, ten miles above Lake St. Croix, only eighteen or twenty feet higher, viz.: in F. 1 e, in a soft gritstone, are abundance of bucklers and post-abdomens of small trilobites, possessing some analogies in

form to the genera *Agnostus*, *Trinucleus*, and *Triarthrus*, (see Pl. 7, Fig. 4,) and probably belonging to more than one species; one of which seems to have been provided with spines, at least two inches in length, curved at the extremity into the form of a barbed fish hook. Fig. 5, Pl. 7, represents one of these, found by Mr. B. C. Macy near the mouth of Miniskah."

Speaking of the distinction between the *lower* and *upper* magnesian limestone formations of the Upper Mississippi, Dr. Owen remarks, page 19:—

"The traveller who has visited the Upper Mississippi cannot fail to have remarked the peculiar outline of hill that bounds the prospect on either side of this picturesque portion of that majestic river. He must especially have noticed the conspicuous perpendicular walls of rock, that rise from out the grassy slope, or green copse wood, in massive cliffs, and terrace the heights as with interrupted natural battlements from the Maquoketa river to Lake Pepin. It is not, however, until the geology of the country has been closely inspected, that he is able to discover that the hills which present themselves to view below Turkey river do not belong to the same geological era as those which appear above the mouth of that stream. Nay, so uniform are they in their general aspect, that the miner himself, who has spent the best part of his days in excavating and exploring their recesses, is wont to regard them as identical. So they are, looking only to their chemical composition. Both are limestones, highly magnesian,* in heavy beds, of great compactness and durability; but they are separated from each other by from one hundred and fifty to two hundred feet of other strata, the upper hundred feet of which teem with peculiar races of fossil forms, constituting a distinct geological epoch, and marking a long lapse of time that has intervened between the period of deposition of these limestones. In my former report I have designated them the "lower" and "upper" magnesian limestones of Wisconsin and Iowa. This distinction, as will appear more fully hereafter, is of the first importance in drawing conclusions regarding the mineral value of the country I have been instructed to explore.

"All the conspicuous escarpments of magnesian limestone, south of Turkey river, are composed of the upper of these formations, whilst all those north of Wisconsin river, as far as Lake Pepin, are of the lower.

"An inspection of hand specimens is in general not sufficient to enable even the geologist to determine from which of these magnesian limestone formations it has been taken, so like are the two in general aspect. Viewed on a large scale, however, some dis-

* The proportion of carbonate of magnesia varies from 10 to 42 per cent.

tinctive peculiarities can be observed; the lower magnesian limestone has both in its upper and lower portion often oolitic beds interstratified; it has occasionally green particles disseminated through it, and on the whole is rather more compact and darker colored. The only certain methods, however, of determining to which of these formations any given rock belongs, is to note the order of superposition; or, still better, to determine the nature of the imbedded organic remains, which differ materially in the two."*

One of the most important results of the survey is the establishment of the fact that the *lower* magnesian limestone as well as the upper, is metalliferous, yielding both galena and copper ore similar to that found south in the Mineral Point District in the upper magnesian limestone.† It appears, however, as yet a matter of doubt whether these ores will be found in as rich profusion in the northern part of Wisconsin as in the Mineral Point and Du Buque Districts.

The lower sandstones of the Upper Mississippi were found to attain their greatest elevation and development a few miles below Mountain Island, or, as it is known to the French Canadian, "*Montagne qui trempe a l'eau.*"‡ From thence with some few irregularities, as indicated by the diagram of comparative heights,

* The paragraphs describing in a graphic manner the physical features of this magnesian limestone, are cited in our last volume on page 307.

† In confirmation of the correctness of the statistics collected in 1839 and inserted in the geological report for that year, regarding the produce of the lead mines situated in the upper magnesian limestone of the Mineral Point and Du Buque Districts of Northern Illinois, Dr. Owen has appended to the present report a table of the actual recorded shipments of lead from Galena from February to December, in the years 1841, 2, 3, 4, 5, 6 and 7, as furnished to him by Mr. James Carter, banker at Galena, Illinois. It is as follows:

Months.	Pigs lead, 1841.	Pigs lead, 1842.	Pigs lead, 1843.	Pigs lead, 1844.	Pigs lead, 1845.	Pigs lead, 1846.	Pigs lead, 1847.
February	.....	.....	.....	.....	5,287	.....	.....
March	4,080	80,125	.....	78,636	97,746	28,841	15,669
April	91,296	65,080	73,449	82,737	104,558	126,073	82,231
May	91,233	46,515	122,224	89,982	93,623	142,489	119,391
June	57,110	37,959	74,475	60,784	87,058	113,209	185,084
July	58,820	54,436	77,333	66,699	68,153	83,559	110,383
August	37,257	43,250	67,233	55,200	107,957	50,257	61,462
September	16,092	39,081	45,400	54,203	63,424	58,827	67,761
October	46,286	54,941	67,473	63,072	78,887	71,668	63,825
November	50,640	26,472	33,734	53,288	71,767	54,291	65,873
December	.....	.....	.....	.....	.....	1,500	.....
Total	452,814	447,859	561,321	624,601	778,460	730,714	771,679
First arrival of steamboats	March 22	March 9	April 10	March 5	Feb. 26	March 10	March 29
Last departure of steamboats	Nov'r. 22	Nov'r. 16	Nov'r. 26	Nov'r. 21	Nov'r. 23	Dec. 2	.....

As a pig of lead will weigh, on an average, 70 pounds, it appears from the above table that the annual produce has varied, in the last seven years, from nearly thirty-two millions, to upwards of fifty-four millions of pounds.

‡ Literally, the Mountain which soaks in the water.

the strata gradually decline; so that at Red Rock the fossiliferous shell limestone and underlying incoherent white siliceous sandstone, which crowned the hills bordering on the lower Wisconsin river, and which soon ran out after passing Prairie du Chien, were again in place, forming the table land. Gradually increasing in thickness towards St. Paul's and Carver's Cave, these beds form there the entire mural ledges above the waters of the Mississippi and constitute the escarpment of Fort Snelling, as well as at the Falls of St. Anthony. Five or six miles above this, these and indeed all the protozoic strata, are seen for the last time in ascending the Mississippi, being lost under the drift deposits which cover all the rocky strata from view to the vicinity of the Sank Rapids where the granite protrudes.

In regard to the physical features of the celebrated country between the mouth of the St. Peter's and the Falls of St. Anthony, we extract the following:

"The Falls of St. Anthony are at present seven miles from the mouth of St. Peter's river. It is, however, more than probable that they once occupied a position at or near Fort Snelling. Of course, little evidence can be gathered of the rate of wearing, from actual observation of the inhabitants recently settled there, but, judging from the condition of the strata themselves, there must have been a rapid retrocession. The cement, which holds together the particles of the St. Peter's sandstone, is so slight that it is with difficulty a solid specimen can be obtained. Yet this is the rock, with a covering only of fifteen or twenty feet of schistose limestone, to protect it from the swift current of the Mississippi, which forms the base of the falls.

"The confused heaps of disjointed masses of limestone, piled together below the falls, indicate the undermining action in progress. The inclined position, too, of the ledges of limestone there, for several hundred yards above the chute, contrary to the local dip, has mostly been produced by the water which sweeps over them, entering the extensive rents which run across the strata at this place, and gradually washing out the particles of sand upon which these ledges repose, thus allowing them gradually to sink, and causing huge blocks to become, from time to time, detached and precipitated into the rapids beneath. In this way the fall will, probably, after a lapse of time, be converted into a rapid. For, in proportion as the fall shall recede, the sandstone, by reason of its dip, will diminish in thickness, and at length disappear beneath the river bed. From observations of the dip at the falls, this latter contingency will occur when the fall has been worn back some six or seven miles from its present position.

"There can be little doubt that the rate of erosion at the falls of St. Anthony must be more rapid than at the falls of Niagara, since the soft sandstone of the former locality is more easily washed away than the Niagara shale.

"On the brink of the gorge, near Fort Snelling, no fluviatile remains have been yet found at a height where the waters may be supposed to have flowed in former times; but Dr. Shumard, who was instructed to collect evidence of any ancient river deposits at a higher level, observed over the limestone at the falls a bed of drift of about eleven feet in thickness, and resting on that, a bed of sand containing species of *Cyclas*, *Limnæa*, *Physa* and *Planorbis*, and this deposit he traced on to the same level for nearly half a mile below the present position of the falls.

"The same gentleman also observed, half a mile below the falls, and about a quarter of a mile east of the gorge, on rising ground over which runs the trail to St. Paul's, a white marl charged with the same genera of shells, but of different species.

"The former of these deposits is doubtless of fluviatile origin, and affords evidence of the river having flowed, for a short distance at least above the gorge; the latter seems to be a lacustrine deposit, the bottom of some drained lake, of which there are numerous instances in the Chippewa land district.

"If we except these beds and the underlying drift, no formations of more recent date than the shell limestones of St. Peter's were observed along the Mississippi from the Wisconsin river to the Falls of St. Anthony. This statement will apply also to the country east of the Mississippi, as far as the water-shed between that stream and Lake Superior, except along the valley of the St. Croix above the falls."—pp. 31, 32.

The 2d Chapter contains a description of the geological formations of the Winnebago Reserve, a tract of country in Iowa lying between lat. 43° and 43° 30′, extending on the west side of the Mississippi as far as long. 93° 30′. Until the autumn of 1848 the Winnebago Indians occupied this neutral ground between the white settlements and the Sank and Foxes; when the former tribe were removed to the Two River country above the Sank Rapids.

The principal streams which water the Winnebago Reserve are: Turkey, Upper Iowa, and Red Cedar. It was along these streams that the examinations were chiefly directed.

We learn from the report that along that [illegible] of Turkey river which meanders near the southern line of this Reserve tract, fossiliferous limestones, of the same age as those above the second terrace at Prairie du Chien, form low ledges crested with cedars and surmounted by a green slope from which the upper magnesian limestone rises in fantastic shaped cliffs.

Ascending the same river to the Indian Agency and Fort Atkinson, the strata gradually rise. At the former locality, the elevated ground usually presents a mural cliff of from fifty to sixty feet high, resting on table land, the elevation of which above Turkey river is about one hundred and forty feet. Here and

there are also isolated, mound-like hills, nearly flat on the top and so symmetrical in form that, were it not for their height and extent and their being composed in their interior of solid ledges of rock, one might be tempted to attribute to them an artificial origin.

The lower strata are more schistose, being chiefly marlites with alternations of calcareous layers. The most conspicuous fossils are: *Leptæna Madisoniensis*, *L. sericea*, *L. alternata*, *Orthis formosa*, *Pleurotomaria bilex*, and *Isotelus megistos*. Others less abundant, are: *Atrypa capax*, *A. exigua*, *Spirifer lynx*, *Trochus bilex*. Several trilobites probably of undescribed species allied to *Phecops;* one near to *P. calicephalus*, but with compound eyes. There was also obtained in this vicinity a specimen of *Bumastis barriensis* which was probably washed from higher ground.

The Upper Iowa for the last fifty miles of its course, flows between cliffs of lower magnesian limestone based on the lower sandstones, which latter, with an interlamination of magnesian limestone towards its upper part, constitutes the greater part of the rock exposure near the confluence of that stream with the Mississippi.

There are many fine examples on this river of those remarkable castellated forms which the lower as well as upper magnesian limestone often assumes. Several sketches illustrating the features of the country, accompany the report.

On the Upper Iowa, about longitude 91° 50′, the following fossils were found in the lower 150 feet of rock: *Leptæna sericea*, *Leptæna rugosa*, *L. Madisoniensis*, *L. deltoidea*, *L. alternata*, *Pleurotomaria lenticularis*, *Cyathophyllum ceratites*, *Coscinopora sulcata*, *Bellerophon bilobatus*, *Isotelus megistos*, *Orthis testudinaria?* *O. formosa*, *Illænus crassicauda*, *Murchisonia bellicincta*, *M. subfusiformis*, *Atrypa capax*, *Orthis subæquata*, *Atrypa hemiplicata*, *Orbitulites? reticulatus?*

In this part of the Reserve the formation is evidently of the same age as that near the Agency on Turkey river, which lies about twenty miles to the south. Both appear to represent the Trenton limestone and Hudson river group of New York, and to be cotemporaneous with the Lower Silurian system of England.

Regarding the formation of the western portion of the Reserve along the Red Cedar river we extract the following:

"On Red Cedar there is a change in the geological formation of the country. Either this is the western limit of the formations of Upper Iowa and Turkey rivers, or else the southwest dip carries the formations before reaching the Red Cedar beneath the water courses; for on crossing the Red Cedar, the first ledges that came under my observation, only a few hundred yards to the west of it, were found to be charged with the large variety of *Atrypa prisca* and a *Spirifer*, very abundant in the shell beds of the falls of the Ohio, and allied to the *S. ostiolata* of the Devo-

nian system of the *Eifel*, if not identical with it. These strata appear to be the equivalent of the rocks described in my report of 1839, as occurring lower down on the same stream in the Dubuque district, so that the line of bearing between these two formations, Silurian and Devonian, seems to run nearly parallel with that stream.

"The Red Cedar limestone extends up its west branch as far as I penetrated, i. e., to near the north line of the Winnebago Reserve; it also stretches away to the west as far as the limits of my observations, viz.: to Willow river. On Shell Rock, the east branch of Otter, I found in it, besides *Atrypa prisca*, casts of *Lucina proavia*, and an undetermined species of *Leptæna*. But the fossil which is most abundant, and most universally distributed through the rocks of this western portion of the Winnebago Reserve, is a very fine structured coral, composed of concentric layers, like the genus *Stromatopora*, but so close together that the layers can only be distinguished by close inspection with a magnifier. On Lime river, the west branch of the Otter, the strata are so full of this close grained coral that it might with propriety be called a coralloid limestone.

"Some of the beds of this formation consist of very close textured and smooth calcareous beds, like the lithographic limestones, splitting with a flat conchoidal fracture. In it I did not observe any fossils; but I had not many opportunities of examining exposures either of it, or, indeed, of any of the other members of the formation in question, along the line of my route. The geologist who undertakes to investigate the vast prairie countries of the Mississippi valley must be provided with no common share of patience and perseverance. He must be content to travel for half a day together without seeing aught but a rich black soil, covered, as far as the eye can reach, even down to the very edge of the small streams, with a thick and high growth of prairie grass, with, perhaps, a faint outline of timber cutting the distant horizon. He must be prepared to wade swamps, to ford streams waist deep, or, in times of freshets, to plunge in and breast the current. He must not shrink beneath a broiling sun, without even a bush to cast a faint shadow over an occasional resting place. He must think himself fortunate, if he can reach, at night, a few scattered oaks to plenish his fire, and boil his camp-kettle; and he may consider it a special instance of good luck, if, in return, he can catch a glimpse of a rock exposure once or twice a day. He may travel for days together without lighting on any object more interesting than the hillock of the prairie dog, or the broad lair of the bison."—pp. 36, 37.

The western portion of the Reserve is said to present no indication of being a mineral country. Some portions of the Turkey river and Upper Iowa country afford a little lead ore.

The third chapter of the report is devoted to a description of the formations of the interior of the Chippewa Land District. In our notice of it we must be brief.

The protozoic strata which have been described as forming the sections on the Mississippi, extend on the east side of the Mississippi for an average distance in a direct line into the interior of fifty to seventy-five miles; that is, to the falls of the principal eastern tributaries of that river. Here the crystalline rocks first appear above the water courses forming low falls and rapids. These igneous ranges do not rise abruptly in this part of the United States into elevated mountains; on the contrary they are seldom seen except in the immediate cuts of the streams, being covered for the most part with drift. The character of the country generally towards the summit levels leading to Lake Superior, is a succession of terraces of moderate elevation, chiefly composed of drift, often having a nucleus no doubt of granite, syenite or hornblende rocks; but these protrude only occasionally. At intervals the streams are ruffled into rapids, being filled with boulders which obstruct materially their navigation. A portion of these boulders may have been transported from great distances; the greater part however appear to be not far removed from the parent rock.

It is matter of surprise that so large an area of the interior of this district, and indeed of the sources of the Mississippi generally, should be level tamarack and cedar swamps, since in approaching a great water shed that gives rise to one of the largest rivers in the world, one is led to anticipate a country with physical features of quite a different character.

Interposed between the crystalline and igneous rocks of the interior of the district and the lowest sandstones, some green and red schistose beds have been observed at different localities. These appear to have been derived from the decomposition and detritus of the more easily decomposing felspathic granites.

The lower beds of sandstone adjacent to the igneous outburst, are not unfrequently changed to a hard quartzite. The red pipestone so highly prized by the northern tribes of Indians, is found also near the junctions of these formations, associated with quartzite.

We learn from the 4th chapter of the report that, except in the valley of the St. Croix, the red sandstones, marlites, slates, conglomerates and associate trap ranges which prevail in the district along the south shore of Lake Superior, extend only as far as the elevated ridges, whence rise the tributaries of the Mississippi on the one hand and the streams emptying into Lake Superior on the other. Over a large portion of this area the solid rocky beds are covered by comparatively recent deposits of drift sand, red marls and red clay; the latter derived apparently from the disintegration of the strata on which they repose; and have been pro-

duced by oscillations of the surface during the more recent periods of uplifts.

At various points along the range of outburst of the igneous rocks, mineral veins have been observed. The examinations had not been sufficiently minute to pronounce on their productiveness. The hypogene rocks observed by the Wisconsin corps through this region of country are: granites, syenite, hornblendic rocks, greenstone, and various kinds of trap.

The highest ridges of the south shore of Lake Superior, situated in the Chippewa Land District, are represented as formed of hornblende rocks, metamorphic slates, syenite and trap. These are estimated to be over a thousand feet above the lake, and are situated from ten to sixteen miles from its shore.

No organic remains had so far been found in the formations of Lake Superior by which to establish their age. Neither had any localities been discovered, where beds of known geological position might solve the question by indicating the relative order of superposition.

The principal mass of sandstone constituting the south shore and west end of Lake Superior in Wisconsin, appears to have a different lithological character from the sandstones beneath the lower magnesian limestone on the Mississippi, described in the 1st chapter of the report. So far as this evidence can be depended on, it militates against the supposition of their geological parallelism.

On the west side of the Mississippi, north of the Winnebago Reserve, as far as the St. Peter's river, the lower magnesian limestone and underlying sandstones prevail as far as the examinations had extended, i. e., for about half a degree of longitude. The former of these formations occupies the greatest area.

ART. II.—*On Rutilated Quartz Crystals from Vermont, and Phenomena connected with them;* by FRANCIS ALGER, A.M., Member of the American Academy, and of the Society of Natural History, Boston.

(From the Proceedings of the American Association for the Advancement of Science, held in Cambridge, in August, 1849.)

Mr. ALGER presented a paper on the quartz crystals from Waterbury, Vermont, containing acicular or capillary Rutile, and exhibited illustrative specimens of great perfection and beauty. He compared them with other specimens from the Alps and Brazil, and pointed out some important phenomena in which they differed from those, and all other rock crystals he had seen.

Erratic masses of rutilated quartz had, from time to time, been found in Waterbury, and several of the neighboring towns, and

they had even been picked up in New Hampshire; but their geological association, or the character of the rock from which they originated, had not been well understood until recently. Mr. Alger had lately visited a remarkable locality of this mineral, where a true vein, two feet or more in width, had been brought to light in making a deep cut through a hill in Waterbury, on the line of the Vermont Central Railroad. The rock is a very tenacious talcose slate, sometimes passing into mica slate, and prevails to a great extent in this part of Vermont. Metalliferous veins are rarely contained in it, but veins of quartz are common. The vein here referred to, consisted principally of common amorphous quartz, presenting internal cavities or druses, lined or studded with projecting prismatic crystals, sometimes colorless and transparent, but more frequently of a smoky color, or brownish yellow tint, (Cairngorm.) The pure glassy white crystals, are but rarely penetrated by the acicular rutile, while the colored varieties abound with it, and seem in fact to owe the intensity of their color to the very prevalence of it through their substance.

The rutile is sometimes grouped in tufts of radiating crystals, proceeding from a common point, and shooting through the quartz; this being also the ordinary manner of its occurrence in the Brazilian specimens. The direction of many of these diffused crystals in the position they now occupy, would seem to show that they had been subjected to some electrical or polarizing influence, by which they had been arranged very nearly in a line parallel with that of the apex or perpendicular axis of the crystals of quartz in which they are imbedded. It would seem that they were once floating, as it were, in the transparent and liquid medium of the silicious mass; or else, what is more probable, in the simultaneous crystallization of both quartz and rutile, slowly or otherwise, there was superadded a polarizing influence which caused them to converge towards one point. Or again, it may be that these peculiarities are confined to those quartz crystals which projected downwards in the cavity of the vein at the time of their formation; and thus the rutile, from its greater specific gravity, would have a tendency to crystallize and extend itself downwards, rather than in any other direction. Mr. Alger could not state from actual observation at the locality, whether such was the fact.* The appearance referred to is most marked in those crystals in

* That mineral veins may owe their origin in many cases to electrical or electro-chemical agencies, has been shown by the experiments of Fox, Becquerel and others, who by ingenious contrivances imitating the conditions which were supposed to exist in nature, have produced precisely similar results, even the formation of various crystallized bodies; but the subject has not been pursued with that direct application to the origin and structure of crystals, in their natural repositories, which it deserves. "Future investigations, (as has been said by Dana,) with regard to the position of crystals in rock strata, especially in granite and allied rocks, may prove that the electric currents in constant circulation around the earth have been active agents in determining the direction in which the axes of crystals lie, and the course of cleavage planes." Dana's Mineralogy, second edition, p. 88.

which the rutile exists in the most delicate hair-like and needle-shaped forms, (*Venus hairstone;*) and, in some instances, these delicate prisms are bent towards the ends most remote from the apex of the quartz crystals. They are sometimes four inches in length.* By transmitted light, their color is reddish brown; lustre like that of polished copper. Some few of the needles are entirely black, and closely resemble schorl. It was the opinion of Mr. Kennedy, a scientific engineer, and a very close observer, who was present at the opening of the vein, that the crystals of quartz enclosing rutile, were confined to one side only of the vein, thus indicating two periods in its formation, in one of which no rutile was present to intercrystallize with the mass. All the recently obtained crystals are very much discolored by iron rust, and the vein appears to be "run out." But its loss will undoubtedly be soon supplied by other sources.

Prof. Hubbard, of Dartmouth College, in whose possession is the finest specimen of this mineral found in the United States, first noticed a most interesting fact in regard to these crystals, namely, that the needles of rutile in some cases, had shot completely through the quartz crystals, and stood out in relief upon their surfaces, as if protruded by the sudden effort of their crystallization. The same appearances were presented to a small extent, by one of Mr. Alger's specimens. If produced in the manner supposed, the quartz must have been in a liquid state; if not produced in that manner, the crystallization of the rutile must have continued after that of the quartz had ceased. The latter seems the most reasonable supposition, and is favored by analogous phenomena in other crystallized minerals.

Imitative forms of mica contained in the Quartz.—The surfaces of two of the large crystals exhibited by Mr. Alger, as well as several smaller fragments of crystals, were covered by minute but very brilliant scales of gold-colored mica; and these sometimes penetrated the quartz in company with the rutile, and, in the same manner, seemed confined mostly to the darkest colored varieties of the quartz. But the appearance presented by this mica, is curious and altogether unique, for in the substance of the crystals, it has assumed the most fantastic forms, appearing in tortuous and vermicular ramifications, some of them bearing such a striking resemblance to organized bodies, as to give the first impression that they are actually the remains of insects or worms. The figures on the next page present a correct representation in a magnified form, of some of the most curious of these appearances exhibited by Mr. Alger's specimens. He had dissected out several of them, and found them to be composed entirely of small plates of mica more or less closely united parallel with the cleavage

* The polished specimens in which these prisms are exhibited, (known in French jewelry as *Flèches d'amour,*) are rarely surpassed in beauty by the finest to be met with in foreign collections. The reticulated forms are thus shown in great perfection.

planes of the mineral. In fact, they are elongated hexagonal crystals of mica, twisted or distorted into every imaginable shape. Their laminated micaceous structure is shown perfectly by the microscope, and is represented by the transverse lines in the figures. The resemblance of the third figure on the fourth row, to some species of Araneides, is not too remote to suggest them instantly to the mind; and the general resemblance of several of the figures to the blood leech and common worms is still more striking—these being produced by the successively diminishing diameters of the little plates of mica until they terminate nearly in a point. But the origin of these resemblances was evidently fortuitous, and could not have been in any way connected with organic matter. They are interesting principally as furnishing a new fact in the department of imitative mineralogy, and they appropriately suggest the term vermiform mica as most characteristic of their general appearance. Vermiform should therefore be included among the imitative shapes assumed by minerals. The striking resemblance between several of these figures and the worm-like projections thrown out by the separating folia of *vermiculite* when exposed to a red heat, will occur to every one who has experimented on the mineral. The following examples of them were obtained by heating a fragment of the pure mineral broken from a specimen lately analyzed in Dr. Jackson's Laboratory. They are of natural size.

2.

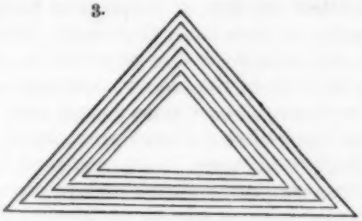
The straight lines seen passing through several of these figures, are intended to show the needles of rutile that actually intersect these concretions of mica in the body of the stone. In some of them the rutile passes through the circular space left by the folding over of the mica, and its crystallization does not seem to be interrupted by the mica in any case. A characteristic feature of rutile, but never shown in any of the specimens from this locality, (i. e., the geniculated forms,) seems to be imitated by the mica, and is best shown by the second figure in the lower row.* The color of this mica by transmitted light, is a pale green, and the mineral seems to agree in external characters with the substance from other localities. Considerable quantity of it was found loose in the vein, mixed with broken crystals of rutile.† The only appearances at all analogous to those just described,

* Prof. Hubbard's specimen presented the appearance in so marked a manner, as to lead to the impression that they were rutile.

† A portion of this carefully separated, was found to lose nearly 15 per cent. of water when heated to the melting point of glass. A peculiar empyreumatic odor was at the same time given out, but there was no reaction of fluorine. Exposed in a platinum crucible to a white heat for twenty minutes, it became grayish black and partially fused into a mass. In this state it was slightly magnetic. The large proportion of water seems to ally it with pennine, or perhaps with hydro-mica from the Alps—*Wasserglimmer* of M. Morin;—while its crystalline form, an oblique rhombic prism changed into a six-sided figure by the truncation of its acute lateral edges, refers it at once to common mica.

which had come to the knowledge of Mr. Alger, were those mentioned and figured by Dr. McCulloch, and described in vol. ii, of the Geological Transactions of London. But in this case, the substance was chalcedony, and the imbedded masses composed of chlorite, had nothing of a crystalline structure, and in fact were rather imitative of vegetable, arborescent forms.

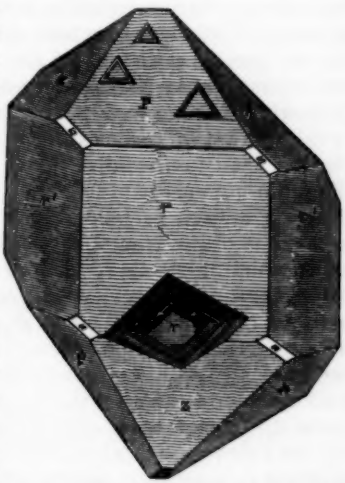
3.



STRIATED QUARTZ CRYSTALS.

The annexed figure represents some of the striæ which appear on the acuminating planes of the crystals, and are parallel with their edges of combination with the adjoining planes, as shown in the figure below. They are usually mere superficial triangular lines so slightly impressed as to be visible only when held in a particular position in regard to the light; but in a few cases, these configurations, commencing at a small point before the crystal had attained its full size, continue to widen with every fresh layer of particles deposited upon the faces of the crystal, until they produce cavities of considerable depth. That they were formed in this manner, is indicated by the step-like appearance of the sides of these cavities—an appearance which is more strikingly presented in a few cavities of a different shape, of one of which the annexed figure furnishes an example. In this, it will be noticed, the cavity is rhomboidal, and might at first be mistaken for the impression left by some foreign substance which had disappeared. No substance having such form, has been found attached to any of the crystals from this place, and although the angles at which the sides meet each other, (about 72° and 108°,)* are nearly those of calc spar, or carbonate of iron, it is evident from the enlargement of the cavity towards the surface of the crystal, or the hopper-like appearance assumed by it, that neither

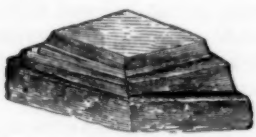
4.



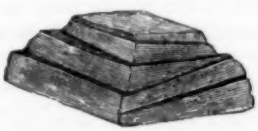
* These angles were incorrectly given in the published Proceedings of the American Association. They have now been obtained by measuring the casts taken from its cavity, instead of the cavity itself.

of these substances could have produced it. The quartz, while depositing itself around either of them, would have taken the exact form of either, precisely as we see such impress of their forms in other crystals of subsequent formation, as for example, in the quartz crystals from Herkimer, New York. So it is evident, that if any substance ever occupied the cavity, it must have received its form from the cavity, without communicating any to it; and thus a pseudomorphous crystal may have been produced in a manner somewhat different from usual: viz., by filling up a cavity which had never been occupied by any crystallized substance whatever. Should such pseudo-crystals of infiltration or deposition, be met with in similar cavities of the quartz from this locality, it will become an interesting enquiry to determine whether they have the same composition, or are various depending upon accidental circumstances. If the view here taken of them be correct, they cannot come under the designation of any of the pseudomorphs hitherto described, (as they do not assume the form of any other crystal which has disappeared,) and we must accept such explanation of them as is afforded by the quartz itself. It is not easy to trace in these cavities, as it is in those before spoken of, any certain relation between them and the crystalline structure of the quartz whose surfaces they impress; their sides are not parallel with any of the striæ as seen upon the faces of the crystals; they indicate an interruption in the process of crystallization, and we have only to suppose a successive retrocession or withdrawal of particles in such parallel directions, thus enlarging the cavity outwardly, as the crystal itself increased in size. They do not appear to have been produced by the irregular combination of two or more crystals or by the union of different crystalline planes leaving spaces between them, because the striations which mark the faces of the crystal, and which have been intercepted by the cavity, appear opposite to each other on both sides of the cavity. This is shown by the figure. It therefore appears to belong to one crystal. The cavity intended to be represented by the large figure measures one inch on a side, and half an inch in depth; the striations at bottom are parallel with those upon the face of the crystal. It is more accurately shown by the following drawings taken from a cast of it in wax, which presents it in opposite positions.* The crystal itself, has a rhom-

5.



6.



* The deep bevelment on the broadest surface of these casts, (not shown in the cuts,) gives the true angle at which the plane *r* of the crystal (see fig. 4) meets plane *z*—the cavity extending partly into one of the planes of the pyramid.

boidal plane on each of the adjacent lateral angles of the prism, and not as is usual, on the alternate angles. It is permeated in every part by acicular rutile. This rutile, in one or two instances, has shot through similar cavities in other crystals, its delicate hair-like needles remaining unbroken while their opposite extremities are deeply imbedded in the quartz. In one of these cavities the depth is more than twice that of the transverse diameter, but the same step-like succession of layers is observed as in the large one, diminishing in their descending order, until they nearly terminate in a point towards the centre of the crystal. Compared with the large cavity, there is greater evenness of outline in these little ridges, and a nearer approach to parallelism between them.

ART. III.—*Examination of Kirkwood's Analogy;* by SEARS C. WALKER.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 212.)

IN order that Kirkwood's Analogy should apply to all the planets of the Solar System, including the interpolated planet between Mars and Jupiter, four fundamental conditions must prevail for each planet considered as the middle of a consecutive series of five; namely:

$$\text{I.} \ldots\ldots a = \frac{(a_{,}+b_{,})c_{,}+(a'-b')c'}{c_{,}+c'}$$

$$\text{II.} \ldots\ldots m = [(a - a_{,} - b_{,})c_{,}]^{2}$$

$$\text{III.} \ldots\ldots m = [(a' - a - b')c']^{2}$$

$$\text{IV.} \ldots\ldots \theta = \frac{2\pi}{\varkappa} \cdot a^{\frac{3}{2}}$$

Where

$a_{,,}, a_{,}, a, a', a''$ = the five mean distances of the planets.

m = the mass in parts of the sun's mass similarly accented.

T = the sidereal year, in earth's mean solar days.

θ = the sidereal rotation in the same.

k = Gauss's *revolution constant* from Kepler's third Law.

$\varkappa$ = a similar *rotation constant* from Kirkwood's Analogy.

$r_{,}$ = the inner radius of the sphere of attraction for the third planet.

r' = the outer radius of the sphere of attraction for the third planet.

$r_{,,}$ = the outer radius of the sphere of attraction for the second planet.

r'' = the inner radius of the sphere of attraction for the fourth planet.

$D = r_{,} + r' =$ Kirkwood's diameter of the third planet's sphere of attraction.

$$a = \frac{a}{D}$$

From these definitions the value of D is thus derived:

$$\frac{m_{,}}{r_{,,}^{2}} = \frac{m}{r_{,}^{2}}$$

$$\frac{m}{r'^{2}} = \frac{m'}{r''^{2}}$$

$$r_{,,} = a - a_{,} - r_{,}$$

$$r'' = a' - a - r'$$

$$\frac{m}{r_{,}^{2}} = \frac{m_{,}}{(a - a_{,} - r_{,})}$$

$$\frac{m}{r'^{2}} = \frac{m'}{(a' - a - r')}$$

$$r_{,}\sqrt{m_{,}} = (a - a_{,} - r_{,})\sqrt{m}$$

$$r'\sqrt{m'} = (a' - a - r')\sqrt{m}$$

$$r_{,} = \sqrt{m}\left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}}\right)$$

$$r' = \sqrt{m}\left(\frac{a' - a}{\sqrt{m'} + \sqrt{m}}\right)$$

$$D = (r_{,} + r')$$

$$= \sqrt{m}\left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}} + \frac{a' - a}{\sqrt{m'} + \sqrt{m}}\right)$$

$$= \left(\frac{2\pi}{\varkappa}\right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta}\right)^{\frac{2}{3}} \cdot a$$

$$b_{,} = \left(\frac{2\pi}{\varkappa}\right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta_{,}}\right)^{\frac{2}{3}} \cdot a_{,} - \sqrt{m_{,}}\left(\frac{a_{,} - a_{,,}}{\sqrt{m_{,}} + \sqrt{m_{,,}}}\right)$$

$$b' = \left(\frac{2\pi}{\varkappa}\right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta'}\right)^{\frac{2}{3}} \cdot a' - \sqrt{m'}\left(\frac{a'' - a'}{\sqrt{m''} + \sqrt{m'}}\right)$$

$$c_{,} = \frac{\sqrt{m_{,}}}{b_{,}}$$

$$c' = \frac{\sqrt{m'}}{b'}$$

$$b_{,} = \sqrt{m_{,}}\left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}}\right)$$

$$b' = \sqrt{m'}\left(\frac{a' - a}{\sqrt{m'} + \sqrt{m}}\right)$$

$$\sqrt{m}+\sqrt{m_{,}}=(a-a_{,})c_{,}$$
$$\sqrt{m'}+\sqrt{m}=(a'-a)c'$$
$$m=[\,(a-a_{,}-b_{,})c_{,}]^2$$
$$m=[\,(a'-a-b')c']^2$$
$$a=\frac{(a_{,}+b_{,})c_{,}+(a'-b')c'}{c_{,}+c'}$$

Computation of the Value of the Constant called $\varkappa$.

If we use Leverrier's* mean distances and masses in his theory of Mercury, with the exception of Adams's† value $\frac{1}{3\,1\,0\,0\,0}$ for the mass of Uranus, and Hansen's‡ periods of rotation, we find by condition (IV.) the following values of

$$\varkappa=\frac{2\pi}{\theta}\cdot a^{\frac{3}{2}}$$

Namely:

$\varkappa=15.179$ by Venus.
$=14.811$ by Earth.
$=15.593$ by Saturn.

Whence, with double weight for Saturn:

$\varkappa=15.300=$ mean value adopted.

If we form another constant $k'=\left(\frac{\varkappa}{2\pi}\right)^{\frac{2}{3}}$ we find

By Venus, $k'=1.9377$
Earth, $=1.9054$
Saturn, $=1.9772$

From which it appears that an approximate value for the rotation times might be obtained from

$$\theta=\left(\frac{a}{2D}\right)^{\frac{3}{2}}$$

But the other formula is preferable; and we have

$$\theta=\frac{2\pi}{\varkappa}\cdot a^{\frac{3}{2}}=\frac{2\pi}{15.3}\cdot a^{\frac{3}{2}}=\frac{\pi}{7.65}\cdot a^{\frac{3}{2}}$$

With this value of $\varkappa$, using the data above mentioned, interpolating the a, m, and θ of the fifth or hypothetical planet, called Kirkwood, and three masses, viz.: of Mercury, Mars, and Uranus, the following normal elements of the primary system are obtained, in which all of the above four fundamental conditions are fulfilled for each middle planet of five. For Neptune, Mr. W. had used his own value of the mean distance, and Prof. Peirce's mass from Bond's measures of the elongation of the satellite. The interpolated values are enclosed in parentheses.

* Additions à la Connoissance des Temps, 1848, 17–26.
† Proceedings R. A. Soc., vol. ix, pp. 159, 160.
‡ Schumacher's Jahrbuch, 1837.

Table of Planetary Elements, conforming rigorously with Kirkwood's Analogy.

Planet.	Mean distance.	Mass in parts of the sun's mass.	Sidereal revolution in earth's mean solar days.	Diameter of the sphere of attraction.
	a	m	θ	D
Mercury*	0.387.099	$\left(\frac{\dagger\ 1}{2802311}\right)$	1.003.473	(0.198.122)
Venus	0.723.333	$\frac{1}{401847}$	0.972.917	0.377.908
Earth	1.000.000	$\frac{1}{\ddagger 354936}$	0.997.270	0.513.934
Mars	1.523.691	$\left(\frac{1}{2107404}\right)$	1.025.936	0.768.429
Kirkwood	(2.908.511)	$\left(\frac{1}{1353240}\right)$	(2.406.104)	(0.830.951)
Jupiter	5.202.800	$\frac{1}{1050}$	0.385.907	5.035.373
Saturn	9.538.852	$\frac{1}{\S\ 3512}$	0.437.003	8.497.477
Uranus	19.182.730	$\left(\frac{1}{23733}\right)$	(1.396.779)	(7.875.342)
Neptune	30.039.500	$\frac{1}{20000}$		

* An interpolated planet with a mean distance a=0.20 and a mass of $\frac{1}{4739670}$ would harmonize with the above system.

† This interpolated mass of Mercury compares with observation thus:—

Leverrier's first mass, ... $\frac{1}{1.909.700}$

Walker's interpolated mass, . . $\frac{1}{2.802.311}$

Leverrier's second mass, . . . $\frac{1}{3.000.000}$

Encke's value, ... $\frac{1}{4.865.771}$

‡ And for Mars:

Burckhardt's mass, ... $=\frac{1}{2.680.637}$

Walker's interpolated do, . . $=\frac{1}{2.107.404}$

§ And for Uranus:

Adams's mass, ... $\frac{1}{21000}$

Walker's interpolated mass, . . $\frac{1}{23733}$

Lamont's mass, ... $\frac{1}{24605}$

Struve's mass, ... $\frac{1}{26860}$

Conclusions from the above table.

From this comparison of authorities, it appears that with a constant value of $\varkappa = 15.300$, and with assumed masses of Mercury, Mars, and Uranus, equally plausible with those heretofore employed, the a, m, and θ, of the fifth or hypothetical planet may be thus interpolated:

$$* \; a = 2.908.511$$
$$m = \frac{1}{1.353.240}$$
$$\theta = 2.239.035$$

And then the system of nine values of a, m, and θ, will be normal with reference to Kirkwood's analogy, and each of the four fundamental conditions (I.) (II.) (III.) and (IV.) will be rigorously fulfilled for every middle planet of five.

Mr. Kirkwood had remarked in his letter,† that his analogy required the assumption of a fifth planet between Mars and Jupiter. If the Geological Section was allowed the privilege of restoring fishes, lizards, and elephants, there was no reason why the Physical Section should not be permitted to restore a planet.

Remarks on the Degree of Constancy of $\varkappa$.

The limits within which it is possible to vary the value of $\varkappa$, without making some of the interpolated elements inadmissible, are about one-twentieth of the adopted mean value of 15.300. We may therefore conclude that, WHETHER KIRKWOOD'S ANALOGY IS OR IS NOT THE EXPRESSION OF A PHYSICAL LAW, IT IS AT LEAST THAT OF A PHYSICAL FACT IN THE MECHANISM OF THE UNIVERSE. The quantity D, on which the analogy is based, has such immediate dependence upon the nebular hypothesis, that it lends strength to the latter, and gives new plausibility to the presumption that this, also, is a fact in the past history of the solar system.

Such, then, is the present state of the question. Thirty-six elements of nine planets, (four being hypothetical,) appear to harmonize with Kirkwood's analogy in all the four fundamental equations of condition for each planet.

To suppose that so many independent variable quantities should harmonize together by accident, is a more strained construction of the premises than the frank admission that they follow a law of nature.

If, in the course of time, the hypotheses of La Place and Kirkwood shall be found to be laws of nature, they will throw new light on the internal organization of the planets, in their present, and in any more primitive state, through which they may have passed.

* The mean distance is greater than that of the asteroids, except Hygeia, which has $a = 3.18$.

† This Journal [2], ix, 395.

For instance, we may compute the distance p, from the centre, at which any planet must have received its projectile force, in order to produce at the same time its double movement of translation and rotation. Now let v = the planet's present angular rotatory velocity. Then, $K = pmv$, will be a constant quantity denoting its momentum of rotation.

If the planet, in a more primitive state, existed in the form of a ring revolving round the sun, having its present orbit for that of the centre of gravity of the ring, the momentum K of rotation must, by virtue of the principle of conservation of movement, have existed in some form in the ring. It is easy to perceive that this momentum K is precisely the amount which must be distributed among the particles of the ring, in order to preserve to all the condition of dynamical equilibrium, while those of each generating surface of the ring were wheeling round with the same angular velocity. It is also clear that this mean angular velocity must be that of the primary planet in its orbit, and accenting the quantities p and v for the case of the ring, we have the equations,

$$K = pmv = p' m v'$$

$$\frac{p'}{p} = \frac{v}{v'} = \frac{T}{\theta} \frac{\varkappa}{k} D^{\frac{3}{2}}$$

$$p' = \frac{\varkappa}{k} . D^{\frac{3}{2}} . p$$

But on the hypothesis that the law of decrease of density from centre to surface in the primitive shape was the same as at present,

Let r = the present radius of the planet;

R = that of the generating figure of the primitive ring;

Then, $\frac{p'}{p} = \frac{R}{r}$

And, $R = \frac{\varkappa}{k} . D^{\frac{3}{2}} . r$

The value of R from this formula, comes out a very small fraction of D for the small planets, and nearly equal to D in the case of Jupiter, Uranus, and Saturn. If any inference can be drawn from this result, it is unfavorable to the hypothesis that the primitive law of decrease of density was the same as the present.

If the planets have really passed from the shape of a revolving ring to their present state, the prevalence of Kirkwood's analogy shows a nice adaptation of parts in every stage of the transition.

If the primitive quantity of caloric (free and latent) had undergone a very great change beyond that now indicated in the cooling of their crusts; if the primitive quantity of movement of

rotation had been different from its actual value for any planet; if the law of elasticity of particles for a given temperature and distance from each other varied from one planet to another in the primitive or present states; in either of these cases, the analogy of Kirkwood might have failed. As it is, no such failure is noticed; we are authorized, therefore, to conclude, that the primitive quantity of caloric,—the law of elasticity,—the quantity of movement of rotation,—the past and present radii of percussion,—the primitive diameter of the generating surface of the rings, and the present dimensions and density of the planets, have been regulated by a general law, which has fulfilled for all of them the four fundamental conditions of Kirkwood's hypothesis.

After Mr. Walker had concluded, Mr. George P. Bond inquired of Mr. W. as to the applicability of his remarks on primary rings to the case of the secondary ring in the system of Saturn.

Mr. W. replied, that in the case of the breaking up of a primary ring, the day of the new planet would be equal to the year of the ring, provided the new diameter was the same as that of the generating figure, and the same law of decrease of density from centre to surface was preserved. In this case we should have

$$K = rmv = r'mv'$$

$$v = v'$$

and therefore

$$p = p'$$

Such, however, is not the case in fact with the primary planets. The new diameter is contracted by the more immediate action of the central mass, more than it is expanded by the increase of free caloric. The new diameter is, therefore, so much smaller than the primitive D, that p' is changed into p, and v', or the yearly mean angular velocity, is changed into v for the daily value.

We may extend the nebular hypothesis, and Kirkwood's analogy to the secondary systems. If they are laws of nature, they must apply to both. In the secondary systems the day and month are the same. This fact has remained hitherto unexplained. Lagrange showed that if these values were once nearly equal, a libration sets in round a state of perfect equality; but he offered no conjecture as to the cause of the primitive equality. On the nebular and Kirkwood's hypothesis, it would only be necessary that upon the breaking up of the ring, the primitive diameter of the generating figure and law of relative density of layers, should be preserved, in order to maintain a constant value of $p = p'$, and consequently of $v = v'$.

Prof. Henry has shown that the moon, and probably the other satellites, by excess of radiation above absorption, have reached their constant minimum amount of free and latent caloric.

Perhaps this is the very condition required to maintain $p=p'$, and consequently $v=v'$. In this case we may conclude that p had exceeded p' immediately after the breaking of the ring, and only arrived at a state of equality by the loss of caloric from radiation.

Prof. Peirce remarked that Kirkwood's analogy was the only discovery of the kind since Kepler's time, that approached near to the character of his three physical laws. Bode's law, so called, was at best only an imperfect analogy. Kirkwood's analogy was more comprehensive and more in harmony with the known elements of the system. The diameter of the sphere of attraction, a fundamental element in this analogy, now for the first time gave an appearance of reality to Laplace's nebular hypothesis, which it never had before. The positive testimony in its favor would now outweigh the former negative evidence in the case, however strong it may have been. It follows at least from Kirkwood's analogy, that the planets were dependent upon each other, and therefore connected together in their origin, whatever may have been the form of the connection, whether that of the nebular hypothesis, or some other not yet imagined.

ART. IV.—*On Kirkwood's Analogy;* by Dr. B. A. GOULD, Jr.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 363.)

THE subject which Mr. Walker brought to the notice of this Section on Saturday, is one of far more than ordinary interest. Besides the elegant simplicity of Mr. Kirkwood's formula, his theory must, if it be confirmed, materially influence our views of cosmogony and of the theory of the Universe. I have devoted all of the time which my duties have allowed since Mr. Walker made his communication, to the numerical examination of the Analogy to which he referred and which prompted his beautiful investigations. I will state the results, though not in the fullness which they deserve, and with which I at first hoped to be able to give them; for although the subject is large, and one which we cannot expect to exhaust for many years, yet the time of the Section is so precious at this late hour, that I shall limit myself to as brief a statement as possible.

Mr. Kirkwood's theory, as regards the rotation of the planets will, if found to be true,—and the presumption seems to-day strongly in favor of its truth—furnish a remarkable and unexpected argument in support of the nebular hypothesis. The minds of many have been wavering of late with regard to this hypothesis; their doubts have been strengthened by the unqualified assertions that all nebulas are resolvable; but this analogy of

Kirkwood tends most strikingly to confirm it—so much, indeed, that if this latter be true, I do not know how any one can resist the argument which it furnishes in favor of the former, in so far as it applies to our solar system. It is then no longer a hypothesis, but becomes a probable theory.

I will give a very short sketch of the quantities I have used in repeating Mr. Walker's computation.

[Dr. Gould then gave upon the blackboard the masses of the planets, and the periods of rotation which he had used, differing from those used by Mr. Walker.]

These are the masses which I have used; and these are the times of rotation as given in the books. I do not know how accurate the latter may be considered; perhaps to minutes, perhaps even less so. I believe they have all been determined by the observation of spots. If so, what proof have we that the spots do not move, no matter what the number of rotations used in determining the period? I have marked the period of Uranus as doubtful, because I do not know upon what authority it rests, having only found it in a table of a popular work by Sir J. Herschel, with a mark of doubt prefixed. It does not agree at all with this theory.

In considering a question of this kind, we must remember the nature of our investigations. The subject is to a certain extent, necessarily general, and the appearance of precise harmony could not be expected even were our data exact, which they are not. The nature of the problem requires a general, not a special agreement between observation and theory. When we are considering the evolution of order from chaos, we cannot pretend to a knowledge of all the physical forces which exerted an influence. We go back to a supposed time when the planetary spaces were filled with nebular matter; we assume the existence of certain nuclei or centres of attraction; and, from our knowledge of the solar system, as it now is, infer the relative force which these several centres of attraction must have exerted, and assign to each its proportionate realm. If now we find that the spheres of influence belonging to the several nuclei are harmoniously connected, by a simple formula, with the periods of rotation as observed to-day,—an element before omitted in our investigations—we discover a remarkable corroboration of the probability of our hypothesis. This is what Kirkwood's formula professes to be—a simple relation between the time of rotation and the diameter of the sphere of attraction.

The subject being then a strictly general one, we are not warranted in demanding that exactness of numerical agreement, requisite for the verification of theories of a more special nature. If, as circumstances appear to indicate, more careful investigation should lead to the general adoption of the theory of Kirkwood,

I should not desire that this should be denominated a LAW. Nature's laws must be precise and complete. The relation which we are considering claims only to be approximate—an analogy. And in speaking of it, I shall call it by this name, *Kirkwood's Analogy*. And where we have by hypothesis a right to expect analogy and not perfect accordance, the want of perfect accordance must not be considered to cast doubt upon the theory. Besides, if Kirkwood's Analogy were the result of a general law, would not the action of the law be modified in all probability by circumstances which would prevent us from perceiving any strict mathematical precision? The considerations which would be strong arguments against hypotheses of other kinds, do not appear to me weighty when applied to any thing so rude as the motion of chaotic matter.

There is a formula known as "Bode's law"—an empirical formula—expressing a supposed analogy, for which no reason was ever assigned and which, even before it was broken by the new planet Neptune, was found utterly devoid of that universality and precision which must characterize all laws of nature. Though it was considered a remarkable coincidence, and perhaps as capable of suggesting some law of nature, no true mathematician could ever have regarded it as a real LAW. Moreover, Gauss had shown long since that it did not hold for Mercury.

This "Law of Bode" was analogous to the theory of Kepler, that as there were but five regular solids, there could be but five planetary intervals, and therefore no planet between Jupiter and Mars.

Kepler's theory was totally overthrown by the discovery of Uranus, as the other has been by the discovery of Neptune. Bode's law, to which, by the way, Bode's name has been improperly given, would make the distance of Neptune beyond the orbit of Uranus nineteen times the distance of the Earth from the Sun, while it is in fact less than eleven times this distance beyond it, so that the fallacy of this formula must now be so evident as to require no demonstration.

Discordances such as those which exist in the application of this law to the planetary system, would afford sufficient reason for rejecting the analogy of Kirkwood; but, with even these discordances, the fact, that a single formula would approximately represent the truth to so great an extent, would justify us in bestowing much time upon its consideration.

[Dr. Gould then gave a brief sketch of the points of connection between the nebular hypothesis and the new analogy,—showing how the one would lead to the other.]

It will be remarked that in the phrase "sphere of attraction," the word sphere is not used in its geometrical sense. Nor is a planet necessarily in the centre of its sphere of attraction, for

upon the one side, as is the case with the earth, may be a planet comparatively near, and upon the other a smaller planet at a greater distance; whence it is evident that the extent of the sphere of attraction will be much less upon the former side than upon the latter.

In Mr. Walker's theory he assumes $\varkappa$, in the equation $\theta=\frac{2\pi}{\varkappa}\cdot a^{\frac{3}{2}}$, to be a constant and equal to $\frac{1}{(k)^{\frac{3}{2}}}\cdot\frac{1}{356.2563744}$, the term k being nearly 2. In the following formulas I shall denote the quantities which refer to the Earth by a single accent, those referring to Mars by two, to Jupiter by four, and to Saturn by five, reserving three accents for the hypothetical planet between Mars and Jupiter. I make use of Mr. Walker's formula for the sphere of attraction as follows:—D being the diameter of the sphere, a being the mean distance of the planet, and m being its mass.

For Jupiter we have

$$D^{\text{iv}}=\sqrt{m^{\text{iv}}}\left(\frac{a^{\text{iv}}-a'''}{\sqrt{m^{\text{iv}}}+\sqrt{m'''}}+\frac{a^{\text{v}}-a^{\text{iv}}}{\sqrt{m^{\text{iv}}}+\sqrt{m^{\text{v}}}}\right)$$

So for Mars;

$$D''=\sqrt{m''}\left(\frac{a''-a'}{\sqrt{m''}-\sqrt{m'}}+\frac{a'''-a''}{\sqrt{m''}+\sqrt{m'''}}\right)$$

In these formulas you will perceive that every thing is known, except the mass and distance of the new planet; or the *old* planet, if you please. The only assumption is the truth of the nebular hypothesis. If we knew the values of D^{iv} and D'', the spheres of attraction of Jupiter and Mars, we should have two equations and but two unknown quantities, a''' and m''', and should thus have this planet restored by the nebular hypothesis alone.

I have assumed in the computation for the value of k, not 2,—the constant which Mr. Walker supposes it to be, not only from his calculations, but from *a priori* reasoning,—but the mean of the values obtained from each planet, using the masses as given in the books, though affected of course, with some inaccuracy.

Now recurring to the above phenomena, let us take, for the sake of convenience,

$$D^{\text{iv}}-\left(\frac{a^{\text{v}}-a^{\text{iv}}}{\sqrt{m^{\text{iv}}}+\sqrt{m^{\text{v}}}}\right)\sqrt{m^{\text{iv}}}=A,$$

$$D''-\left(\frac{a''-a'}{\sqrt{m''}+\sqrt{m'}}\right)\sqrt{m''}=B,$$

and then we have,

$$\frac{m'''}{m^{\text{iv}}}A=a^{\text{iv}}-a'''-A,$$

and hence $$\sqrt{m'''}=\frac{a^{\text{iv}}-a''-(A+B)}{\frac{A}{\sqrt{m^{\text{iv}}}}+\frac{B}{\sqrt{m''}}}$$

Here all the quantities on one side are known, and we use the mass of the new planet thus obtained for the solution of the problem. This being substituted in either of the previous equations, will give us the mean distance of the planet.

Or, if for convenience we make $\frac{A}{B}\sqrt{\frac{m'''}{m^{iv}}}=C$

we shall have— $$a''=\frac{a^{iv}-A+(a''+B)C}{1+C}$$

Now the only question is as to the value to be adopted for Mr. Walker's constant, which it seems to me should be deduced from observation only.

In computing the value of k, I obtain for

Venus, ...	1.9374
Earth, ...	1.9030
Saturn, ...	1.9763
The mean of this, ...	1.939

is the quantity assumed for k, in obtaining the results of which I shall speak; these three planets being the only ones to which the formula can be applied. It will be seen that the values obtained are most confirmatory of Mr. Walker's results. Unless we suppose the nebular matter to have been equally distributed through the solar system, we could not expect to find k absolutely *constant*, even if it were an approximation to the number 2.

Prof. Walker here remarked that the constant used by Dr. Gould answered better than the constant 2.

Dr. Gould continued,—We do not know the extent of Mercury's influence inside its orbit, and hence cannot know the diameter of its sphere of attraction. Nor can we apply the formula to Mars or to Jupiter, for we do not know what planet may have been between them. We cannot apply it to Uranus, for we do not know its period of rotation. There remain but the three planets mentioned above.

Calculating, from the equations thus developed, the mass and distance which would belong to a planet between Mars and Jupiter, and thence, by Kirkwood's analogy, the corresponding time of rotation, we do not find it so great, that, by mere centrifugal force, the planet could have been exploded, and its mass scattered in the form of asteroids.

From a very rough computation of the place and size of the hypothetical planet, I obtain a mean distance 3.12,—and a mass $\frac{1}{3\,8\,1,3\,3\,3}$. This mass is very much smaller than the mass of our earth, and would agree with the supposition of a small planet, smaller even than Venus, but would be at least equal in size to twelve or fifteen Asteroids.

This gives rise to a great many speculations, most interesting and important in their bearing upon the theory of the universe. I wish to dwell upon the fact that we neither know accurately the period of rotation, or the mass of most of the planets. The only element which is really well known, is the distance of the primary planets from the sun. Then there is the difficulty to which I also alluded, in ascertaining the magnitude of spheres of attraction, that we cannot assume the nebulous matter to be equally dense; so that it cannot be demanded that the analogy should be very accurately expressed by any given data.

It is now extremely important that observations should be made upon the periods of the rotation of several planetary bodies, and it is much to be desired, as bearing upon this problem, that those who occupy themselves with what may be called the natural history of astronomy should determine the times of rotation anew, and thus enable us to decide upon the truth of a law, the discovery of which may be important in the history of astronomy.

Prof. Walker made a remark on Saturday, with reference to the position to which Mr. Kirkwood will be entitled, should his theory be found true. The Section seemed surprised at this remark. I do not wish to express myself strongly, but certainly when we look back upon the labors of Kepler, who strove so many years with results so unpromising, until he discovered the laws which underlie the whole fabric of our solar system, and then turn to Mr. Kirkwood, a teacher in the interior of Pennsylvania—who without the sympathies of kindred minds, or the use of any library of magnitude—without calling even upon the aid of strict mathematical analysis—has fixed his attention upon this one problem, and investigated it in all its bearings, until after ten years of patient thought and labor, he has arrived at such a result as this—we cannot but be struck with the similarity of the two cases; nor can we consider it as very derogatory to the former to speak hereafter of Kepler and Kirkwood together as the discoverers of great planetary harmonies.

ART. V.—*On the Natural Terraces and Ridges of the country bordering Lake Erie;* by CHARLES WHITTLESEY, of Cleveland, Ohio.

THROUGH the assistance of the engineers, engaged at various times, in surveys for railroads and canals in Northern Ohio, I have been enabled to determine the elevation of our "Lake ridges" at numerous points, between the Pennsylvania line and Sandusky Bay, a distance of 130 miles. I am more particularly indebted for these levels to J. H. Sergeant, Esq., who has run several lines west of Cleveland, and to Messrs. Harback and Smith, engineers for the Cleveland, Painesville and Ashtabula Railroad Company.

When these surveys do not cross the ridges and terraces, they have still been the basis upon which by short cross levels taken with a pocket instrument, I have obtained the elevations; and the results I think, cannot be wide of the truth.

There may be an extreme discrepancy of three feet among them, however, arising from changes in the surface of the Lake, which is the common plane of reference.

My opinion has been for many years, that the "*ridges*" are not "ancient beaches" of the Lake, although some of the *terraces* may be. It is indispensable to a beach, that it should at its foot or water line be *perfectly horizontal*. The Lake ridges are not so; and this fact, taken with the external form which they assume, clearly gives them the character of *submarine* deposits.

There are points on this coast where there are four ridges rising in succession from the Lake, as in the township of Ridgeville, Lorain County. In other places there are *three*, as from Geneva to Ashtabula; from Euclid through Painesville to Geneva, two; and from Cleveland to Euclid, one. There are places where it is difficult to trace any; and in others as at the city of Cleveland, where there are two or three branches or divisions of one ridge for short distances, all about the same level and liable to terminate suddenly. The ridges are sometimes upon the crest of a terrace, and sometimes lie, like a highway of water-washed sand, on the gently inclined surface of a plain, that descends towards the Lake. From a regular and beautiful elevated roadway, the ridge occasionally breaks into sand knolls, as at Avon Centre, Lorain County; at Ohio City near Cleveland, and at Painesville, Lake County.

Where nothing to the contrary is stated, the height given is that of the summit of the ridge, terrace or knoll. The first ridge, or that nearest the Lake, is known in the county as the "North Ridge." The others have different names at different places; as the "Middle Ridge," "Chesnut Ridge," "Butternut Ridge," and "South Ridge."

Elevation of the North Ridge, beginning at the Eastern part of the Western Reserve.

Conneaut, Ashtabula Co., above Lake Erie, . .	120 feet.
One mile west, ...	145 "
Four miles east of Ashtabula village, . . .	132 "
(Base of same for several miles, 85 to 95.)	
County line between Lake and Ashtabula Co., northern slope of North Ridge, .	107 "
Eight miles west in Lake County, . . .	125 "
Centreville, 1 mile north of village, . . .	105 "
Painesville, ...	120 "
Mentor—well defined for 2 miles level, . . .	109 "

Willoughby,	85 feet.
Seven miles east of Cleveland,	112 to 118 "
Three " " " "	113 " 118 "
Two " " " " at crossing of Cleveland and Pittsburg Railroad,	128 "
Cleveland city,	96 to 108 "
Ohio City,	114 "
Rockport, Rocky River,	90 "
One mile west,	105, 107 and 126 "
Avon, Lorain Co., east of Centre one mile,	85 "
" " " Centre sand knolls,	105 "
Russelton, Lyme, Huron Co.,	120 "

This table embraces a distance of one hundred and twenty (120) miles, where it appears the lowest summit is 85 feet, and the highest 145, showing a difference in longitudinal direction of 60 feet. I have not visited all the positions here given, but the greater part of them, and for the rest am informed by the engineers that there is no higher ground between the ridge and the Lake. In all cases there is a smooth uninterrupted plain, on the Lake side, over which the water of the Lake is everywhere visible, when the forest timber, which is heavy, is cleared away. It is variously composed of blue marly clay, of coarse drift called "blue" and "yellow hardpan," and of coarse sandy and gravelly drift; but the soil is for the most part clayey, and wet between and below the ridges. The streams, little and great, cut deep and steep gullies through the superficial deposits, and also into the rocks below. From the cliff limestone at Sandusky, eastward and to the state line, the superficial matter rests on slates, sandstones and shales, corresponding to the Hamilton, Chemung and Portage groups, of the New York Reports.

Elevation of the second Ridge, called the "South" and "Middle" Ridge.

Near Kingsville, Ashtabula County, (south ridge,)	152 feet.
Centreville, " "	122 "
Two miles east of Cleveland, " "	135 "
Two miles southwest of Ohio City, middle "	149 "
Dover Centre, 12 miles W. of Cleveland, " "	163 "
Rockport, 7 miles " " " "	130 "
Ridgeville, Lorain County, " "	168 "

This ridge is more broken and less continuous than the first, or "north ridge," and is in general heavier. In Rockport, Dover and Ridgeville, on the northern or Lake slope, it is from 16 to 20 feet above the base at its foot, and on the rear 5 to 10 feet. Behind it, as with all the ridges, is flat, swampy land, and small rivulets that drain the low ground, running parallel with the

swell, to some creek, or occasionally breaking through towards the Lake. These lands are very rich, and with a moderate expense are drained by ditches cut through the ridge. The slope of the flat lands between and before the ridges is sufficient to carry off all the water in ditches that have a free current. Most of this land is coming under the plough in this manner, although it is equally well calculated for grass. No country can possess more rural beauty than that along these "ridge roads." The land in a longitudinal view, is apparently level, as far as the eye can reach; and the buildings congregated along the line of the road appear to be arrayed in curved lines, gently waving to the right and left as you proceed. Looking from one of the interior ridges, which are generally perceptibly higher than the next one towards the Lake, if the timber is not standing, another, and rudely parallel row of farm houses, barns, orchards, &c., is seen at the distance of one, two or three miles; the intermediate space perfectly smooth and cultivated, and beyond lies the blue water, and the horizon.

The composition of one ridge does not materially differ from another. It is formed of coarse, water-washed, yellowish sand, or of fine gravel, principally the comminuted portions of the adjacent rocks. The rocky fragments are not generally worn perfectly round, or oblong, as beach shingle is, but are more flat, with worn edges. There are mingled with the sandstones and shales that compose this gravel, scattered pieces of quartz, flint, also granite, and trappean rocks, limestone and ironstone.

The basis of the ridge corresponding with the impervious clayey soil between, gives rise to a great many springs on the Lake or lower side; and this water frequently deposits bog iron ore, that has been used extensively in furnaces along the lake shore.

From near Dover Centre, west to Elyria, and even to Vermillion River, the second or "middle ridge," rests on a coarse grained sandstone or "grindstone grit," which farther east in Cuyahoga County rises above the level of the Lake ridges. Between the Black and Vermillion rivers, I have not succeeded in procuring the elevations. Here they are well developed, and show more branches or collateral lines, extending from one ridge to another, than is observed farther east.

By digging shallow wells, the inhabitants find water in abundance, and generally good. In these wells from 12 to 18 feet deep, there are thrown out as a common occurrence, sticks, timber and leaves, in a decaying state. I have in my cabinet some pieces of this wood, furnished by Dr. Moore of Dover, who took it from a bed of carbonaceous matter in a well of his, twelve feet below the surface. The well is situated on the middle ridge, 163 feet above the Lake. Pieces of timber six inches through have been

found, represented as being water-worn like drift-wood. Those in my possession are solid, with a very fine grain resembling the willow.

Dr. Moore, an intelligent physician of my acquaintance, says he has seen shells thrown from the bottom of wells, resembling "periwinkles," a common name for Lymnea. Similar shells in fragments are said to have been thrown from a pit two miles west of Cleveland, on the north ridge. In the "blue marly clay" beneath this ridge, I have found a Helicina, and a Planorbis, shells characteristic of the loess of the Rhine, and of St. Louis, and the Wabash in Indiana. The palæontological evidence is therefore, as far as it goes, in favor of the idea of very recent and fresh water deposits.

It will be seen from the second table of heights, that the greatest difference is there forty-six feet; and that the summit of the ridge rises, from Rockport to Dover in seven miles, thirty-three feet, but from Dover to Ridgeville, six miles, it is nearly level.

Through these two distances, making thirteen miles, the height of the ridge above its base is about the same, from sixteen to twenty feet; and consequently the base has an equal rise in a longitudinal direction. Two miles west of Ridgeville Centre, the top of the middle ridge has descended from 168 to 149 feet. The foot of the north, or first ridge, and of the terrace on which it is frequently situated, approaches nearer to a horizontal line than the ridge itself, but still differs from a perfect level. It is at

Conneaut Creek,	75 feet.
Four miles east of Ashtabula,	85 "
Several miles west of "	95 "
Painesville,	85 "
East of Willoughby, several miles,	60 to 65 "
Three miles west of Willoughby,	60 "
Euclid Creek, 12 miles east of Cleveland,	75 to 85 "
Seven miles east of "	105 "
Two " " "	102 "
Ohio City,	75 "
Rockport,	70 "
Avon,	70 "

It is not easy to determine with precision where the base or foot of a ridge graduates into the plain; and consequently there is not that accuracy in the elevations for the base, just given, that we attain when measuring the summit or crest. But they are a close approximation, and although remarkably uniform, are by no means equal, as they should be if the base of the ridge represented an ancient coast-line; the greatest difference being forty-five feet, or about the same as the variation along the top of the second ridge.

There are but few measurements in my reach of the third and fourth ridges. In Huron County, south of *Russelton*, there are two low swells of land parallel with the shore, apparently about on a level with each other, and not much above the main ridge at Russelton, which is reported at 120 feet.

The third ridge, in Ridgeville, Cuyahoga County, is one mile southerly from the second or "middle ridge," and is not very prominent, rising six to ten feet above the low ground. At this place it is 186 feet above the lake, or eighteen feet above the middle ridge, and eighty-one above the highest part of the north ridge in Avon, five miles north.

The fourth or last and highest well defined Ridge.

2½ miles southwest of Ohio City, . . .	173 feet.
1¼ miles southeast of Ridgeville Centre, . .	203 "
West bank of west fork of Black River, Elyria,	195 "
Distance embraced, twenty-five miles.	

The materials of the most southerly or interior ridge, are in general coarser than in the others, showing a more violent or less lasting aqueous action. This is observed everywhere at the west. The more *elevated the drift*, the more does it exhibit the effects of *strong currents* in the transportation of large pieces of rock, in the shape of coarse gravel. The lower portions, especially those that lie near the surface of the great Lakes, not only on Lake Erie, but on Michigan and Superior, are fine, argillaceous or marly, laminated, and with few pebbles.

The terraces have not been as much noticed as the ridges, and consequently their height is not as well known. From Rockport to Avon, the north ridge is upon the edge of a terrace, the foot from seventy feet above the lake, down to sixty feet; its crest from one hundred and five down to eighty-five. Directly opposite this, about five miles more inland, a considerable portion of the fourth or south ridge, (known as the "Butternut,") is also on a terrace of about twenty feet, on its northern face; in fact all the ridges partake of the nature of terraces, in places; the northern slope being generally the longest. But the geological composition of the terrace on which the ridge rests is different, and either a rock or a drift of more compact and resisting kind.

Between Newburg and Euclid, nine miles, the northern face of the terrace is very bold, its base from 120 to 150 feet, and its crest 200 to 225 feet. It is here composed of fine grained sandstone (Waverly), and blue and red shales. East of Euclid, the terrace sometimes divides into two, the lower one supporting the north ridge. It is the same for several miles east of Willoughby, the crest of the first or lowest terrace being about one hundred feet and its base seventy to eighty feet, and formed of blue hardpan

resting on shales. In Erie County, on the line of the Mansfield railroad, it is composed of cliff limestone supporting black slate; its base about 130, and its summit 180 feet.

It will be interesting now to compare the elevations above given, for ridges in Western Ohio, with those of the great lakes in other states. In Michigan, at the east line of Washington county east of Ann Arbor, is a well-defined ridge running nearly north and south, whose summit is 140 feet above Detroit River, at Detroit. Around Monroe, in Wayne county, Michigan, are some irregular sand ridges, not more than thirty feet. They are also visible on the north shore of Lake Erie, in the flat country between Erie and Huron; their elevation is not known, but they are apparently as high as 200 feet.

Mr. Roy, a Canadian engineer, has made a section across the ridges back of Toronto to Lake Simcoe, as reported by Mr. Lyell, and has given their respective elevations as follows:

No. 1.—one mile north of Toronto, 20 to 30 feet high—base above Lake Ontario, ...	108 feet.
No. 2.—2½ miles from Toronto, 50 to 70 feet high—base above Lake Ontario, ...	208 "
No. 3.—5 miles from lake—10 feet high—summit,	288 "

Five other ridges *or terraces* are given by Mr. Hall, in the geology of the 4th district of New York; also on the authority of Mr. Roy, referring apparently to the elevation of their base.

No. 4.—above Lake Ontario, ...	308 feet.
No. 5. " " "	344 "
No. 6. " " "	420 "
No. 7. " " "	680 "
No. 8. " " "	762 "

Mr. Lyell observed *eleven* ridges between the Lake and the summit for Lake Simcoe, the elevation of the eleventh, or last and highest, corresponding with No. 7, of the New York Report. The elevation of Lake Erie above Ontario is generally stated at 332 feet, so that the three first ridges or terraces, in rear of Toronto, are below the surface of Lake Erie.

Mr. Barrett, a New York engineer, furnished Mr. Hall with the height of some points on the Lockport ridge, south of Lake Ontario and opposite Toronto. They are as follows:

At Lockport, ...	158 feet.
Middleport, 10 miles east, ...	185 "
Albion, Orleans county, ...	188 "
Brockport, Monroe county, ...	188 "

None of these correspond in height with those on the north shore, as they should do if they were the result of littoral action

at a beach, for the surface of the water would be level. If we suppose them to have been formed in that manner, when the water stood at the base of a ridge, the rivers must have discharged at the same level. Here should, on that hypothesis, be found deltas, and evidence of bays or lagoons. The waters having settled away, at the present period the streams discharge at a lower level, their channels being worn deeper and larger, cutting through the ridges and terraces that lie between the present and the ancient level. If the ancient mouth was at a point different from that where the present channel cuts a ridge, it should be visible in the present form of the ridge. If it was at the same point, there should be marks of such action as always accompanies the meeting of running currents with dead water. But our streams appear to cut the ridges as though they were barriers preëxisting, and broken through by the current.

Terraces composed of the rocks or other general deposits of a country, appear to be much stronger proof of ancient shores than limited sand ridges. When we rise above 240 feet from Lake Erie, the well defined terraces disappear; and from that line to 600 to 650 feet, the general elevation of the table land in Northeastern Ohio, the surface presents a confused arrangement of heavy drift, covering the rocks at various depths, in long massive knolls, without ranges or parallelism. Towards the west, the summits of the lake streams are lower, and the present surface of Northwestern Ohio and Northern Indiana, of Illinois, Michigan, New York and Canada West, with much of Wisconsin and Iowa, would be submerged by a sea rising 250 feet above Lake Erie, or 815 above the ocean.

The Wabash and Maumee summit, at Fort Wayne, Indiana, is 246 feet above Lake Erie. The summit between the waters of

Saginaw Bay, and of Lake Michigan, .	108	ft. above	L. Erie.
Summit between Pishtaka and Rock River in Illinois, ...	218	"	"
Lake Winnebago, ...	177	"	"
Summit between Lake Ontario and Lake Simcoe, Canada, ...	197	"	"
Mouth of St. Peter's River, Fort Snelling, Minesota, ...	179	"	"
Missouri River at Fort Leavenworth, west line of state of Missouri, ...	181	"	"

If, therefore, the relative level of the land was the same as now, when the diluvial sea existed at high levels, its extent must have been very great, at the supposed stage of 250 feet above Lake Erie. At this or any other supposable stage, if it remained stationary long enough to form cliffs and banks at one place, it would produce the same effects, in kind if not in degree, at another; and we should be able to trace beaches or shores over all

the vast west, for such cliffs are due to the action of winds and waves, always in operation on bodies of water. But under-surface currents are not universal, or in such general operation as to form everywhere, bars and longitudinal banks or spits. If the Atlantic Ocean should suddenly settle one hundred feet, or any other distance, would there not remain a distinct shore, well defined and traceable its entire length? At the mouth of some rivers and bays or inlets, would be seen limited sand ridges, their bases upon an exact level. On the ancient bed of the sea opposite sandy coasts, like North Carolina and New Jersey, would appear long, narrow and rudely parallel ridges, of such materials as are easily moved by currents, that would *not* be level longitudinally.

The evidence of the existence of ancient currents acting upon the drift, regularly and irregularly, is abundant. They have acted at all elevations, as well on the highest lands in Ohio at 1350 feet above the tide, as at the sources of the Mississippi, 1680 feet. The evidence is that they were powerful, and in general erratic or irregular and fitful. Such currents would not leave ridges, but rounded elevations. For this discussion it is immaterial whether the relative change in the level of land and water was due to subsidence or upheaval. The change has taken place, and before that period there were at great depths currents of water, both gentle and strong, giving form to the present exposed surface of the earth.

It is to this wide-spread power that we must resort, to explain most of the diluvial phenomena which are observed. What can be reasonably assigned to the wearing action of waves along a coast line, is limited and not pervading; not an universal, but a local, tardy and inefficient geological agent.

ART. VI.—*On the Quantity of Heat evolved from Atmospheric Air by Mechanical Compression;* by JOHN GARRIC, M.D.

PHYSICAL science teaches us that condensation of matter is, with a few apparent exceptions, an invariable source of heat. Atmospheric air, subjected to mechanical compression, evolves it in large quantities, and in proportion to the degree of force applied. But though this general fact is well known, and has been examined by numerous and able experimenters, the numerical quantities of heat furnished by given volumes, under given pressures, have never been accurately ascertained. It may, indeed, be said that there is scarcely a subject in the whole range of natural philosophy, which has elicited more discordant results.

Every phenomenon of nature possesses in itself an interest well calculated to excite the mind to an investigation of its cause.

In acquiring a right understanding of the part it plays in the general system and economy of nature there is a gratification independent of all pecuniary or selfish considerations. But in the solution of the question, "what is the quantity of heat given out by the condensation of air?" there is a more immediate interest arising from the practical use to which the fact may be applied. It is favorable to the interests of science that the prospective value of the knowledge has justified experiments on this subject, as objects of commercial speculation; for otherwise its full elucidation would require an outlay of money too heavy to be expended by the mere lover of nature.

The atmosphere, from any thing we can observe taking place in it, affords but a remote and insignificant idea of the extensive relation existing between it and heat. Our sensations may indicate suffering from diminution, or inconvenience from exaltation of temperature, and the thermometer may mark the extent of its changes; but neither furnishes us with any evidence of the absolute or even the comparative quantity of caloric in air. Other considerations, however, present us with reasons for believing that it contains more of the principle of heat, in proportion to its absolute quantity of matter, than any other body found in a natural state.* Though not experimentally demonstrable, it cannot be doubted that the aerial form of the atmosphere, like that of vapors, is caused by the presence of a definite amount of heat.

Air may be condensed and dilated any number of times, and there will be with each change, a simultaneous and proportional diffusion and absorption of heat. The determination of the quantities of caloric thus alternately set free and rendered latent, is, apparently, a simple problem, which it is generally thought can be easily solved. But to furnish precise results not only is science and experimental skill demanded, but quantities of air must be used which imply a magnitude of apparatus, with facilities for manipulation, such as private philosophers can rarely command. It is true that if "instruments be exceedingly exact, and an experimenter be fully equal to the task of using them properly," the error upon moderate, may be quite as small in proportion as upon large quantities of most substances. But in this assumption, qualifications are implied to which few experimenters can lay claim; nor when possessed, would they be adequate to insure perfect accuracy in operating upon so attenuated a fluid as air which larger apparatus might attain.

In the attempts to determine the quantities of heat set free or absorbed by changes in the volume of air, these principles are well

* According to what are considered the most accurate experiments and deductions on this subject, the absolute heat of atmospheric air, estimating it from the standard of the absolute heat of water, viz. 1,000—is 18,000. See Mudie on the air, page 115.

illustrated; they have been rendered very difficult and replete with errors, from the delicacy of manipulation employed, and the consequent minuteness of result to be ascertained. Limited by the convenience and necessity of economy, philosophers, in their experiments on this subject, have been in the practice of using very small quantities of air. Thus narrowed, the endeavors to ascertain the quantity of heat evolved by the condensation of such a fluid, surrounded as it must be, by a comparatively great weight of matter, and extent of conducting surface, have produced an apparent effect so insignificant, or the means of measuring it have been so imperfect that it cannot be said truth has been approached.

In an investigation for the improvement of science, and still more when it is proposed, as in the present instance, to apply it to practical purposes, it is highly important to fix and determine essential data. So indispensable are they to any useful result, that too much care and nicety cannot be spent on them; because when once done with the accuracy of truth, they not only lay a foundation, upon which we may without rashness hazard fame and fortune, but they save much labor by forming a constant for any number of calculations, or any modification of experiments. In regard to air, the change in its sensible temperature, under an increase of density, is known to be great from the fact that by its sudden compression we may inflame tinder, and many other substances immersed in it. This trivial experiment, although in itself too indeterminate to found a valuable conclusion upon, has formed the basis of many chemical researches, having for their object the solution of the question in view.

To aid in determining the precise temperature to which compression would elevate gases, M. Thenard, many years ago, made a number of ingenious experiments. In trials with gases other than air, chlorine and oxygen, he used fulminating powders which exploded at different temperatures; and thus found that substances which decompose at 205° Centigrade, or 401° Fahrenheit, exploded in hydrogen, azote and carbonic acid, when compressed suddenly and strongly by hand in a glass tube. These experiments indicate that a very considerable accession of temperature may be obtained from the condensation of gases which are not supporters of combustion; but, admitting that atmospheric air conforms to the same law, the force employed is too vaguely expressed to show a precise relation between the heat evolved, and the compressing power. They are, however, interesting as proving that considerable intensity of heat may be obtained by trivial means, under unfavorable circumstances.

About the same time that M. Thenard made his experiments, M. Colladon instituted others better calculated to determine an

exact limitation of the heat set free from air by compression. He states that to ignite sulphur, it is necessary to reduce atmospheric air to one-eighteenth of its volume, and to set fire to starch, to one-thirtieth.*

Philosophers, in their experiments on air, have been in the practice of dividing it into certain proportions—as the half, the fourth, the eighth of the volume experimented upon—and of considering each division as affording an equal measure of heat as the result of condensation. Now, the number of such divisions in reducing air to one-eighteenth of its volume, is a little more than four, and to one-thirtieth, nearly five; while the temperatures at which the above named substances burn, may be stated respectively, at nearly 500° F. and 600° F. Here we have data, which if correct, would at once solve the question involved. By dividing these numbers by each other we shall have as the result of the compression of air, about 120° F. for every reduction of it to half its previous volume. If these data could be relied upon, the subject would need no further investigation; but so different have been the conclusions from analogous experiments in the hands of the other philosophers, that new and more satisfactory ones are demanded. For while, as we have seen, M. Colladon says it requires a condensation of atmospheric air equal to one-thirtieth of its volume to ignite tinder, M. Gay Lussac, who made similar experiments on a larger scale, estimates that a reduction to one-fifth is sufficient.†

Nor have other experiments and processes of reasoning, for deducing a precise solution of this apparently simple question, though conducted by the most eminent chemists and mathematicians of the past and present ages, been more uniform or more satisfactory. The methods of proceeding have been different from each other, and from those already referred to, but they show a similar variance, of from one to five and upwards, in their deductions.

Dalton found, in experimenting with the common air-pump of the laboratory, that if the density of air be suddenly doubled by compression, its temperature rises 50° F. This experiment is among the earliest we find on the subject, and comes, if we can regard the 50° F. as computed at the standard of the specific heat of water, nearer the truth, for the first reduction of air from its ordinary temperature and pressure, to half its volume, than any subsequently recorded.

According to some experiments of Leslie, conducted upon a somewhat different plan, it would appear that atmospheric air

* American Journal of Science [I], vol. xx, p. 180.

† It will be shown in the course of this communication, how this very great difference in apparent result, may arise from comparatively small errors of the experiments.

rarefied until its density was three-fifths of its natural density, when suddenly restored acquired about 48° F. of temperature.

Professor Espy states as the result of experiment, that if air have its density doubled or be reduced to half its volume, its temperature will be increased about 90° F., and that air expanded to half its density, or double its volume, generates a cold of about 90° F.

That accurate and profound mathematician, the late Mr. Ivary, has attempted to deduce from calculation, upon data to which I have been unable to get access, the precise quantity of caloric given out by the condensation of atmospheric air. According to his estimate one degree of heat is evolved from it, when under a condensation equal to $\frac{1}{1\frac{1}{8}}$ of its volume; and consequently, if a volume of air be reduced to half its bulk the heat given out will be equal to 180° F. Both Laplace and Leslie, in attempts to reconcile the calculated velocity of sound, with that which is deduced from experiment, made similar calculations; but the theorems by which they are expressed are both abstruse and inaccurate, for though they regard the quantity of heat evolved from air by condensation as "profuse and powerful," the amount the latter assigns is less than that mentioned by Mr. Ivary; and his estimate, it will be seen, does not equal the truth.

The researches of M. Gay Lussac, to whom science is more indebted for an extensive and profound investigation of this subject than to any other philosopher, led him to consider a condensation of air into one-fifth of its volume as sufficient to ignite tinder—a degree of heat which he states is almost 580° F. This estimate, applied to volume, according to what has been mentioned as the custom of experimenters, would give about 280° F. for every time the density of air was doubled.

Upon a subject on which so many scientific men have directed their attention and tasked their ingenuity to discover methods of accurate observation, it would seem presumptuous to attempt to devise processes more exact than have been already employed. Yet the diversity in the results furnished by such able experimenters renders questionable the truth of any of them, and shows that their modes were defective, or, at least, that fresh investigation is necessary to enable us to confirm or reject their data with certainty. That in the general economy of nature the relation of caloric to air is of high importance, and that the investigation of the laws of their action is worth the labor they may require, and is indeed one of the most interesting enquiries, in both a scientific and practical point of view, to which the attention of mankind can be turned, are apparent from considerations already alluded to.

To improve our knowledge of these relations, so as to deduce the laws by which they are governed, we must study the subject

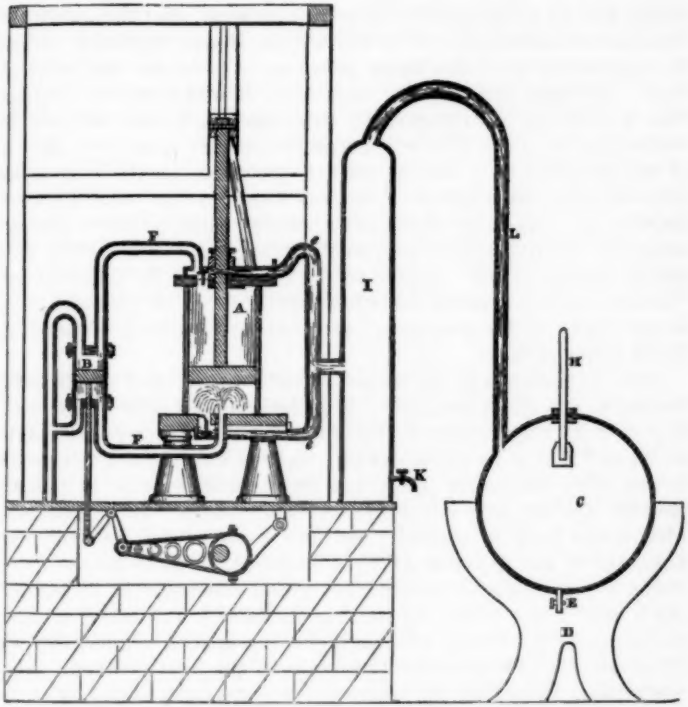
on a larger scale than it has been heretofore examined; and with an object in view sufficiently valuable to justify the expenditure of money for adequate machinery, and of time for a long series of careful and precise observations. Experiments on a small scale, upon a material so attenuated as air, can scarcely be expected to speak absolute truth, or to answer the question as to what is the actual result of large operations. And besides being on a scale of suitable magnitude, they cannot be made accurately by rude and unskillful hands; they must be performed by persons qualified by knowledge and practice to conduct them through all the circumstances which a great range of temperature, and a variety of degrees of condensation may present. By conjoining expectations of pecuniary profit with philosophical views, it has been placed in my power to fulfill these conditions, and by a long course of expensive experiments, amidst much embarrassment of many kinds, to elicit a near approach to truth. A portion of the money expended in conducting these experiments, was furnished by some commercial gentlemen of the city of New Orleans.

As the object of these gentlemen, in advancing their money, was pecuniary gain, and this depended upon the quantity of heat absorbed, or in other words, the quantity of cold produced, and its applicability to the manufacture of ice, from the expansion of air after its condensation, I was constrained to pay as much, perhaps more attention to the evolution of this effect than to the quantity of heat disengaged by the condensation. Two series of experiments were thus carried on at the same time, and each was made to act as a check upon the accuracy of the other; while no labor or care was spared to render both accurate. To make these experiments, a large and powerful machine has been constructed, planned for measuring alike the heat developed by condensation, and the heat absorbed by rarefaction of any volume of air—from two cubic feet to two thousand cubic yards or more, and under any degree of condensation from two to eight atmospheres. By operating with such masses of air, the errors into which previous experimenters had fallen, have been, in a great measure avoided.

In the present article I propose to give an account of the quantity of heat evolved by the condensation of air under a compressing force of from two up to eight atmospheres consecutively; and in a succeeding number of this Journal to show the quantity absorbed by the expansion of the same air from a tension of two, four, and eight atmospheres, to the ordinary atmospheric pressure.

The machine, already mentioned as constructed, was intended for measuring alike the heat evolved by the condensation of air, and the heat absorbed by its subsequent expansion. The portion

employed for the former purpose is represented in the figure below, which is an end view of the whole machine, and consists essentially of a large double acting force pump, A; a smaller force pump, B; and a reservoir or air magazine, C.



The larger pump, A, is constructed on the common principles, well known to mechanics, of the double acting force pump for air or water; and its object is the condensation of atmospheric air. It receives the air through valves, which may be constructed like the induction valves of the low-pressure steam engine, but which, in the present instance, are placed in the lids, opposite to each other, and open inwards. After compressing the air to the required degree, this pump forces it through eduction valves into the pipes *e*, *e*, which lead to the reservoir. The pump is thirteen inches in diameter with a twenty-four inch stroke of piston; and consequently, has a capacity, exclusive of the space occupied by the piston rod, of 3144 cubic inches.

Besides this large pump there was a smaller condensing pump, (not seen in the figure,) four inches in diameter, seventeen

inches stroke, and, after deducting the average space occupied by the piston rod, of 206 cubic inches capacity. This pump was fitted with valves, and communicated with the reservoir, in the same manner as the larger pump. Its object was to charge the reservoir with air to any required tension before setting the larger pump and its antagonistic engine in operation, and thus save the enormous consumption of power which, it was supposed, would be required to work the larger pump so as to obtain the same effect. Though theoretically necessary, it was found in practice that it could be advantageously dispensed with, and will not be introduced into any future construction of the machine. But as it was attached to it, and in most of the experiments to be hereafter detailed, its measure of air was condensed at every stroke of its own and the larger piston, its operation must be taken into account in estimating the heat evolved by the condensation of a given volume of air. Added to the capacity of the larger pump, (3144 + 206 =) it made the whole quantity of air condensed by every stroke of the pumps or every half revolution of the engine, 3350 cubic inches.

The smaller pump, B, is also double acting, and of 56 cubic inches or one quart capacity. It is designed to inject that quantity of cold water through the pipes F, F, and a sieve-like plate, or "rose" placed in the upper lid, and several perforations in the lower lid of the larger pump, and thence distribute it, in a finely divided shower into the interior of that pump. Its object is to absorb the heat of elasticity set free from air by its condensation, and at the moment of its generation, so as to lessen materially the mechanical power that would otherwise be consumed. As it effects this object by mixing intimately the water and air, and causing the former to absorb the free heat, it renders the water an excellent approximate measurer of the heat evolved. After performing this office the water passes out of the pump, with the condensed air, into the reservoir.

The reservoir, or air magazine, C, employed in these experiments, is cylindrical in form, eleven feet in length, thirty-two inches in diameter, and has a capacity of about sixty-two cubic feet. It is made of sheet iron, with hemispherical heads, in the manner of a steam boiler. It is furnished with a safety valve about three inches in diameter, and loaded with a weight, through the intervention of a lever. At one end it has a man-hole affording admittance into its interior; and it is provided with a stop-cock, E, inserted into its most dependant part, through which the water of injection, received from the pumps, and precipitated from the air by its greater specific gravity, may be discharged into the open atmosphere, or returned again to the pump, B, for a renewal of its duty. It is supported by three cast iron frames, one of which is represented at D.

When the air attains a certain pressure in this reservoir, it is allowed to discharge itself, by means of a communicating pipe, into an engine which works expansively through a valve so constructed, as to permit of being arranged to cut off the communication with the reservoir at any portion of a stroke. The air in this way, and independent of the safety valve, is prevented from attaining more than a certain degree of pressure.

There were several appendages to the machinery employed in these experiments which were not absolutely necessary, and would not be used in a practical application of the principle. Among them is the vessel, I. This was a reservoir of a former experiment, and was used, in this instance, to separate the water of injection from the condensed air, the former of which passed through the cock, K, while the latter proceeded through the pipe, L, into the reservoir, C. It is mentioned, and represented in the drawing, in order that all the circumstances attending the experiments may be understood.

As a means of measuring with precision the pressure of air in the reservoir, a gauge consisting of a glass tube, closed at the upper end, having a length of twelve inches, and an internal diameter of a quarter of an inch, was used. After filling this tube with dry air, and inserting it through the upper surface of the reservoir, into a cup of mercury, in communication with the air within the reservoir, it was found to act as a convenient manometer capable of giving the same indications, by the contraction of the contained air, as would have been given in similar circumstances by a column of mercury, placed as in the barometer, and of a height due to the density of the air. The accurate graduation of this instrument presented some difficulties, and was approximately attained by filling it with successive equal-weighed portions of mercury, and marking on the glass tube, and a metal scale surrounding it, the volume thus indicated. These marks were intended to express the scale of heights of the mercury, above its original level in a cup, in atmospheres of thirty inches in height. The instrument requires for perfect accuracy, corrections for changes of atmospheric temperature, as well as for the increased temperature of the air enclosed in the reservoir. But disregarding these sources of error, and probably some in charging the tube with mercury, it was found to be a valuable instrument; its indications were not only more easily attained, but were more accurate than those of the steam indicator, or common safety valve.

The standard which I have relied upon, in conducting the experiments of this research, for determining a measure of heat, is the assumed quantity required for the conversion of a pound of ice into water. In the absence of any experiments of my own

upon the subject, I have taken the quantity at the generally received one of 140° F., though some observations incline me to consider it as several degrees less.

With the foregoing apparatus numerous experiments have been made; but as a small number, conducted on proper scientific principles—more particularly if they agree with each other, and have been, as in these instances, checked by the observations of two persons—are as satisfactory as any greater number, I have detailed, and given the calculations in full of only a few. These will serve as examples for any one who is disposed to compute from the observed data, the resulting quantity of heat obtained, and thus prove the truth, or error of the reported result. Finding that observations were made with more accuracy in proportion as experience familiarized me with them, I considered that the later ones were more to be trusted than the earlier, and I have, therefore, with one exception, selected them for this communication. The exception referred to, is contained in the first of the following tables,* and was the earliest experiment made by me with the machine I have just described. It is introduced for the reasons that it cannot be materially inaccurate, and that the temperature of the atmosphere at the time, was very different and much lower than at any of the later experiments.

It is proper to remark that in conducting these delicate experiments many causes of error have been either unavoidable, uncorrected, or overlooked. Owing to defects of mechanical contrivance and unskillful workmanship, incidental perhaps to every new device, and a noviciate intercourse with practical mechanics, the machine was not capable of performing all its duties with the accuracy the natural laws involved called for. And notwithstanding a great desire to avoid and correct errors from the leakage or irregular working of the machine, by compensating for them, I cannot in all cases rely upon the correctness of the allowances made therefor.

The thermometers used in these experiments were manufactured in New Orleans, and their indications differed so much from each other that they could not be fully relied upon. The nature of the investigation required instruments that should mark, if possible, the tenth part of a degree of Fahrenheit; but none that I could obtain was of sufficient sensibility to be read accurately within half a degree; and, therefore, all indications set down as more minute, must be regarded as conjectures, or interpolated calculations. As I found that no two thermometers agreed with each other, I was aware that it was desirable one or more should be verified by a comparison with the in-

* See continuation, in next number of this Journal.

dications of an unquestionable standard, but this was not attainable. One common source of error, however, in the observations of the thermometers was avoided. Apprehensive from the smallness of their scales of graduation that difference of vision might lead to error, I was careful to obtain frequent observations from two or more persons, and in no instance, where there was a difference of opinion, was the observation recorded. Still, it is possible that the conclusions arrived at may in some instances be inaccurate; for I found that when observations were made by two persons on the same thermometer, they often differed from each other as much as a degree, and there is reason for supposing that even when alike they might be erroneous. I have dwelt upon the possibility of error from the imperfection of both thermometers and observers, because from the mode of experimenting adopted, a slight difference between the actual heat evolved and that observed, would present a very considerable difference in the proportion in the air itself.

The want of a barometer prevented any modifications in the calculation of results, on account of variations in the density of the air.

(To be continued.)

ART. VII.—*On the Computation of the Sun's Daily Intensity at the exterior surface of the Earth, and Secular Changes of Heat;* by L. W. MEECH, A.B., Preston, Ct.

THERE are reasons for believing that the phenomena of solar heat may be as completely interpreted by analysis as are the tides of the ocean. The subjoined contribution is offered in pursuance of this object.

I. Before proceeding to the general investigation, let it be proposed to determine the diminution of heat arising from the secular decrease of the eccentricity of the earth's orbit: in consequence of which, the orbit approaches to the form of a circle, and the earth is constantly removing to a greater distance from the sun, between the apses; the transverse axis remaining invariable. Let then e represent the eccentricity, regarded as constant for one year; ϱ, the radius-vector; φ, the mean anomaly; and θ, the true anomaly, for any given time. Also it is known that $\pi\sqrt{1-e^2}$ expresses the whole area of the ellipse; and $\int\frac{1}{2}\varrho^2 d\theta$, that of the elliptic sector corresponding to θ. Whence by Kepler's law of equal areas,

$$\pi\sqrt{1-e^2} : \int\tfrac{1}{2}\varrho^2 d\theta :: 2\pi : \varphi, \text{ or}$$

$$\frac{1}{\varrho^2} = \frac{d\theta}{d\varphi\sqrt{1-e^2}}.$$

Since heat varies "inversely as the square of the distance" ϱ, this equation evidently measures its intensity. To obtain the sum of the intensities in a year, the equation must be multiplied through by the uniform $d\varphi$, and integrated between the limits o and 2π: then rejecting the constant factor 2π, there remains the relative

$$\text{Annual amount of heat} = \frac{1}{\sqrt{1-e^2}}. \qquad (1.)$$

Again, let the slight decrement of e in one or more centuries be denoted by h; writing $e-h$ in place of e and developing for the first power of h by Taylor's Theorem; there results the proportional

$$\text{Secular diminution} = \frac{-eh}{1-e^2} = -eh - e^3h - \ldots \qquad (2.)$$

On January 1, 1801, the value of e was 0·01678357, with a centurial decrement of −0·00004163, the centurial value of h. And at this rate the orbit would become a circle in 40,300 years, though it is improbable that it will reach this limit. The diminution in a century is readily ascertained by substituting the values of e, h, in the last formula, which gives −0·000 000 69; and it will be shown hereafter in the computation for Mendon, that such numbers are nearly or quite proportional to the corresponding degrees of Fahrenheit's scale. Hence the secular decrease of the annual quantity of heat, arising from secular change of the sun's distance alone, is too small to be sensible to the thermometer in a hundred years, in a thousand, or in ten thousand years, and scarcely so, at the utmost limit, when the orbit becomes a circle. For even then, the mean temperature on the equator, which is now 82°, would not fall more than 0·025 of a degree of Fahrenheit.

It is thus demonstrated that the mean annual heat received by the earth as a whole, is virtually constant during a sidereal year, so far as secular change of the sun's distance alone is concerned; and by reason of the nearly constant excess, the same may be concluded of the tropical or civil year.

II. Again, let it be proposed to ascertain *the sun's relative intensity at any given instant during the day.* For this purpose,

Let L = the 'apparent' Latitude of the place,
D = the sun's meridian Declination,
Δ = the sun's semi-diameter,
A = the sun's Altitude, and
H = the Hour-angle from noon.

The horizontal projection of the sun's disc on a plane at the exterior surface of the earth is well known to be an ellipse; and

if 1 denote the sun's radius, 1 will likewise denote the semi-conjugate axis of this projected ellipse; while the horizontal projection of 1, which is $\frac{1}{\sin A}$, will be the semi-transverse axis. The area of the elliptic projection is therefore $1 \times \frac{1}{\sin A} \times \pi$. But the intensity of the same quantity of heat being inversely as the space it covers; the reciprocal of this area $\frac{\sin A}{\pi}$, or rejecting the constant divisor π, *sin* A *will measure the sun's intensity at the altitude* A, supposing the distance to be constant.

But the sun's intensity further varies inversely as the square of the distance, that is, directly as the square of the apparent diameter or semi-diameter of the disc. Hence

$\Delta^2 \sin A$ measures the sun's intensity at any given instant during the day.

To assign the value of sin A, by spherical trigonometry, the sun's distance from the pole or co-declination, and from the pole to the zenith or co-latitude, and the included hour-angle from noon H, are given to find the third side, or co-altitude. The well-known formula for this case becomes, by writing sines instead of the cosines of their complements,

$$\sin A = \sin D \sin L + \cos D \cos L \cos H, \text{ and}$$
$$\Delta^2 \sin A = \Delta^2 \sin D \sin L + \Delta^2 \cos D \cos L \cos H. \quad (3.)$$

At the time of the equinoxes, D becomes 0, and the expression of the sun's intensity reduces to $\Delta^2 \cos L \cos H$. That is, the degree of heat at different places, then, decreases from the equator toward each pole, proportional to the cosines of the respective latitudes. At other times of the year, however, a different law of distribution prevails, as indicated above.

The sun's intensity at a fixed distance being as the sine of the altitude, it follows that the sun shining for sixteen hours at an altitude of 30°, would raise the temperature of a plain as high, as if it shone for eight hours from an altitude of 90°, or from the zenith, since sin 30° is ·5, and sin 90° is 1.

III. Proceeding now to the general problem, it is required to determine the quantity of heat radiated upon a given place at the exterior of the earth on any given day. The quantity radiated at any instant, has already been made known, as $\Delta^2 \sin A$: hence multiplying the last equation above by the uniform dH, and integrating,

$$\int \Delta^2 \sin A \, dH = \Delta^2 \sin D \sin L \,.\, H + \Delta^2 \cos D \cos L \sin H. \quad (4.)$$

Regarding H as a semi-diurnal arc, the second member will express the daily quantity of heat for a half day, and so for the whole day. Also by integrating between the limits of any two hour-angles H′, H″, the quantity of heat will be found for any

assigned part of the day. The sun's declination has here been taken as constant, and it might easily be shown that what the sun radiates by rising earlier than the implied time, is compensated by a uniform change of declination producing an earlier setting sun.

For testing this formula, the intensities were computed for the 15th day of each month, on the latitude of Mendon, Mass., and the results were found to agree very nearly with those observed at that place about *one month later*,* as follows: the observed values are taken from the American Almanac for 1849, and are derived from fifteen years' observations.

Computed values.			Observed values.	Difference.
January 15, ...	5040	23°.3	24°.3, February 15, ..	+1°.0
February 15, ...	7142	33°.1	33°.5, March 15, ...	+ .4
March 15, ...	9764	45°.2	45°.8, April 15, ...	+ .6
April 15, ...	12574	58°.3	55°.0, May 15, ...	−3°.3
May 15, ...	14482	67°.1	64°.5, June 15, ...	−2°.6
June 15, ...	15346	71°.1	71°.8, July 15, ...	+ .7
July 15, ...	15085	69°.9	68°.9, August 15, ...	−1°.0
August 15, ...	13437	62°.3	61°.0, September 15,.	−1°.3
September 15, ...	10860	50°.3	48°.5, October 15, ...	−1°.8
October 15, ...	8080	37°.5	38°.9, November 15, .	+1°.4
November 15, ...	5638	26°.1	27°.7, December 15, .	+1°.6
December 15, ...	4510	20°.9	26°.0, January 15, ...	+5°.1

It may be proper to observe that the preceding formula was divided by sin L, a constant factor; and the numbers in the second column were then successively computed: their sum divided by twelve, gave 10163 as the mean, to be compared with 47°.1, the observed mean at Mendon. Then as 10163 : 47°.1 :: 5040 : 23°.3, Jan. 15, etc. Let it also be observed, that the Mendon values are the monthly means, which do not always fall on the 15th day, but nearly so.

Before applying the formula further, let it be simplified by means of the astronomic equation, $-\cos H = \tan L \tan D$.

Dividing and multiplying the above intensity by $\sin D \sin L$, and at the same time substituting $-\cos H$ for its equal; and $\tan H$,

$$\text{Daily intensity} = A^2 \sin L \sin D (H - \tan H). \qquad (5.)$$

This expression is much simpler than the one before employed, and by thus computing the temperatures for different places, and comparing the results with those actually observed, the extent of local causes will be disclosed. The ease with which daily and monthly temperatures may now be computed, it is believed will render this formula valuable in meteorological researches. It is

* Since writing the above, I find it elsewhere stated that the observed epochs of maximum and minimum temperature in the North Temperate Zone fall about a month later than their expected times at the solstices. The reason assigned for this circumstance is, that for about a month after the summer solstice, the earth continues to receive during the day more heat than it loses at night; and conversely after the winter solstice, it loses more heat during the night than it receives during the day.

to be mentioned here, that H is an arc of a circle whose radius is 1, which will readily be found by reducing the degrees and minutes, to minutes, and multiplying them by sin 1′, or by multiplying the minutes in time by sin 15′; also using the natural tangent of H, with its trigonometric sign. When the computation is for one place only, sin L being a constant factor may be rejected, leaving,

$$\text{Daily intensity} = \Delta^2 \sin D\,(H - \tan H.) \qquad (6.)$$

For example, the results are subjoined for Calcutta, in latitude 22° 35′ N.; the observed temperatures follow the computed, in order:—

January,	59°.2;	65°.1	July,	92°.3;	82°.6
February,	69°.2;	70°.0	August,	88°.9;	82°.9
March,	79°.5;	78°.1	September,	82°.5;	82°.4
April,	88°.0;	83°.3	October,	72°.6;	81°.0
May,	92°.0;	85°.5	November,	61°.8;	73°.4
June,	93°.1;	84°.7	December,	56°.2;	66°.6

From this it appears, that at midsummer about one-tenth of the heat received is carried away by those upward currents which produce the trade-winds, by sea-breezes, and the conducting power of the soil; also a less quantity of heat is restored by the ground, and by winds in mid-winter.

IV. Is the temperature of summer and of winter in the southern hemisphere, the same as with us, at equal latitudes? On this point, the formula $\cos H = -\tan L \tan D$, clearly shows that the length of the day there is the same as in the northern hemisphere six months later. The difference of temperature is therefore limited to the values of Δ^2. Now the earth being nearest the sun at the northern mid-winter or on January 1st, Δ^2 is at that time measured by $\frac{1}{(1-e)^2}$; while at mid-winter in the southern hemisphere Δ^2 is as $\frac{1}{(1+e)^2}$. The difference is $\frac{4e}{(1-e^2)^2}$; or the proportional difference, taking our mid-winter's temperature as 1, is

$$\frac{4e}{(1+e)^2} = 4e - 8e^2 + \ldots = 0{\cdot}06 \text{ nearly.}$$

The southern mid-winter is therefore from 1° to 2° colder; and the mid-summer from 4° to 5° hotter than at an equal latitude in the northern temperate zone, as will appear by multiplying the Meudon values by 0.06. This advantage of the northern hemisphere is due to the advance of the perigee in longitude of 11″.8 per year, which in time will return to the southern hemisphere the advantage we now possess. The summer season of the southern temperate zone being hotter, is also shorter by about eight days than in the northern hemisphere; which difference is ascribed to the more rapid motion of the earth about the perigee.

V. Are the winters now, as cold as at the first settlement of New England? The impression generally prevails that the winters are growing milder, and the spring is later than formerly. Certainly the snows have not been so deep as in the days of Cotton Mather; neither has Boston bay nor the Chesapeake of late years, been frozen over, as far as the eye could reach. So far as this change is astronomic, and not the result of local changes, it may be determined by means of the formula

$$\text{Daily intensity} = \Delta^2 \sin D\,(H - \tan H).$$

In the first place, let it be proposed to ascertain the change of each factor, for the last two centuries, which will refer the formula to the epoch of A. D. 1650, the period of our colonial history. The first factor Δ^2, depends for its value on the anomaly θ, which has an annual change of $11''.8$, and on the eccentricity e, which has a secular variation of 0.000041. Accordingly, introducing these increments into the analytic expression for the inverse square of the radius-vector, which is the value of Δ^2, and developing by Taylor's Theorem, it is found that both sources of variation cannot affect the present values of Δ within the fourth significant figure, in two centuries: hence these sources of change may be safely neglected in the present calculation.

The second factor, $\sin D = \sin\omega \sin T$; where ω denotes the obliquity of the ecliptic, and T the sun's longitude. Since the tropical or civil year is the interval between two successive returns to the same longitude, sin T ought in the present case to be regarded as constant. But in referring back, ω has a secular increase of $45''.7$, or $91''.4$ in two centuries. Let this increment be denoted by ω'', and the contemporary increment of D by D''. Then developing for the first power of each in the above equation, by Taylor's Theorem, $\cos D \cdot D'' = \cos\omega \sin T \cdot \omega''$. Here substituting the value of sin T from the preceding equation, and dividing by cos D,

$$D'' = \cot\omega \tan D \cdot \omega''.$$

For the third factor involving the semi-diurnal arc H, astronomy gives $-\cos H = \tan L \tan D$; and developing as before, by Taylor's Theorem, $\sin H \cdot H'' = \tan L \cdot D'' \div \cos^2 D$. Substituting for D'' its value found above, also dividing by the preceding equation, $-\cos H = \tan L \tan D$,

$$-\tan H \cdot H'' = \frac{\cot\omega \cdot \omega''}{\cos^2 D}.$$

Recurring now to the formula of daily intensity, let it be denoted by S, at the same time developing for the first power of the increments of the two variables, D, H; the resulting increment is

$$\frac{S}{\sin D}\cos D \cdot D'' + \frac{S}{H - \tan H}\left(1 - \frac{1}{\cos^2 H}\right) H'', \text{ or}$$

$$S \cot D \,.\, D'' - S \tan^2 H \,.\, H'' \div (H - \tan H).$$

And substituting the values of D'', and H'', it becomes

$$S \cot \omega \,.\, \omega'' + S \tan H \cot \omega \,.\, \omega'' \div (H - \tan H) \cos^2 D,$$

which may further be reduced, and dividing by S, the *proportional* secular

$$\textit{Increment of heat} = \cot \omega \,.\, \omega'' (H + \tan H \tan^2 D) \div (H - \tan H). \quad (7.)$$

Lastly, restoring the value of S, there results the *absolute* secular

$$\textit{Increment of heat} = \mathcal{J}^2 \sin D \cot \omega \,.\, \omega'' (H + \tan H \tan^2 D).$$

At the time of the equinoxes, D, and with it this increment becomes zero: the greatest values may hence be inferred to prevail near the solstices when D equals ω. For example, computing by formula (7) the proportional increment for December 15, on the latitude of Mendon, and multiplying into the observed number of degrees, it appears that two centuries ago, the mid-winter was colder by 0°.035 F., and the mid-summer hotter by 0°.025 F.: that is, the temperature of the year is growing more equable by slight gradations. It has already been shown in IV, that the year is remarkably so, compared with that in the southern hemisphere.

That the spring is now later, may be accounted for, by the fact that less snow falls, and the ground being uncovered, has, during the winter, radiated more heat into space, and so at the opening of spring is colder than when covered through the winter by a deep stratum of non-conducting snow. And in general, any variation from the mathematical laws here demonstrated, must evidently be looked for, as the effect of cultivation or other terrestrial causes. Besides, as the sun is the great source of the change of seasons, winds, evaporation, etc., these laws, especially the formulas in III, may yet serve as a basis for computing *a priori* the dew-point, monthly humidity, and range of the barometer.

Lastly, among other secondary causes which tend with striking uniformity to counteract extremes of heat and cold, is the vast size of the sun. Were the same amount of light and heat radiated from a body smaller than the earth, the effects would be restricted to a smaller portion of the earth's surface. But as it is, the sun constantly illuminates half the earth's surface and a belt around the earth sixteen miles wide besides, which may be termed 'the zone of differential radiation;' and this is yet very much widened by atmospheric refraction. The effect of this arrangement is evidently to maintain a warmer temperature, besides rendering the transitions more mild and gradual. In conclusion, the evidences of stability of temperature demonstrated in the present article, it is proper to observe, strikingly accord with the authoritative declaration, that, "while the earth remaineth, seed-time and harvest, and cold and heat, and summer and winter, shall not cease."

ART. VIII.—*Notice of Fossil Bones from the neighborhood of Memphis, Tennessee;* by JEFFRIES WYMAN, M.D.

THE specimens of fossils here noticed were kindly sent me for the purposes of description, by Prof. B. Silliman, Jr. They were obtained from the region of Memphis, by Mr. Lawrence of Louisville, and, as is supposed, from the diluvium of the Mississippi. They are representatives of the following genera of mammals, viz., Mastodon, Megalonyx, Castor, Castoroides. They all present points of interest, especially the last three, which belong to genera whose remains are either quite rare or but very imperfectly known.

As yet, our knowledge of the osteology of Megalonyx is far behind that of the allied genera Megatherium and Mylodon; its dentition likewise is but very imperfectly understood. Many fragments of bones and teeth of Megalonyx doubtless exist in public and private collections in this country, which are yet undescribed. Any notices of individual specimens, especially of the teeth, which may be published, will be of great value to the paleontologist in enabling him to form more complete ideas of the organization of this most interesting race of extinct animals as well as of its geographical distribution.

The remains of Castoroides are exceedingly rare and are known only from a lower jaw and some of the bones of the extremities, discovered in Ohio, and described for the first time by Mr. J. W. Foster from fragments of bones discovered by Dr. Dickerson in the neighborhood of Natchez, Miss., and a cranium nearly entire found in the town of Clyde in New York. Although the Castoroides has so wide a geographical distribution, the above constitute the only localities excepting the one noticed in this communication, references to which have fallen under my observation.

The remains of beavers in a fossil condition would seem from the absence of published reports, to be quite as rare as those of the preceding genus. Doubtless many of them exist in cabinets, but have not yet found their way into scientific journals or treatises. Notices of their remains would likewise be of great interest, if for no other purpose than to establish their identity with, or dissimilarity to, the existing species, or to determine the former geographical distribution of these animals on the North American continent. The remains of Castor Europæus, (which by some has been regarded, though on insufficient grounds, as identical with the American species,) have been found in England, generally in peat bogs,* in the marls of Perthshire and Berwickshire in Scotland,† and on the continent in the valley of the Somme

* Owen. British Fossil Mam. and Birds, p. 190.
† Lyell. Principles of Geology, vol. iii, p. 326.

in Picardy,* in the peat of Flanders, and on the shores of Lake Rostoff.

In this country Prof. Spencer F. Baird, in an interesting communication to the American Association for the Advancement of Science, states that in one of the caves in Pennsylvania, he has found the remains of recent beavers associated with bones of recent species of wolves, foxes, bears, rabbits, muskrats, otters, lynxes, panthers, &c., as well as with some bones, about five per cent. of the whole, of extinct species.† I have not been able to find any notice of remains of beavers found in the United States in a fossil condition. At present, beavers are confined to the more northern districts, extending as far as the Mackenzie river, lat. 67° or 68°, though we have occasional notices of their existing as far south as the mountains of North Carolina, (S. B. Buckley in Am. Journ. Sc., vol. iii, [2], p. 434,) and in several places in Alabama, (Prof. R. T. Brumley in Am. Jour. Sc., vol. iv, [2], p. 285.) They have been found likewise near Peter's mountain in Virginia, near Ashville, N. C., near Milledgeville, Ga., in Dallas county, Ala., and Flanders county, Ky. Dr. Bachman thinks they formerly existed over the whole continent as far south as the tropic of Cancer.‡

No. 1. *Mastodon giganteum.*—This was one of the earlier teeth of a young Mastodon; the longest diameter of the crown was 1·8 inch; its transverse diameter at the posterior edge was 1·6 inch, and at the anterior 1·2 inch, allowance being made for the enamel which is in part deficient. The points of the crown have been entirely worn off, the grinding surface is quite oblique, highest on its outer edge, somewhat excavated, and very beautifully polished. At the posterior inner angle the crown is worn below the level of the enamel, but on its outer face remains of the bases of three ridges are still visible, invested with their coating of enamel.

The remains of two roots or fangs still exist, one of which had been almost wholly absorbed, and the other had the length of an inch, although absorption of its extremity had obviously taken place. The small size of this tooth, together with the existence of but three ridges on the crown, indicate that it was the third tooth in the series.

No. 2. This is likewise a tooth of a young Mastodon, but larger than the preceding. The crown was more worn, its surface less oblique, and more deeply excavated. On one of its margins, vestiges of three ridges remain, and in addition a vestige of a rudimentary fourth ridge. The longest diameter of the grinding surface was 2·7 inches; its larger transverse diameter 2·1, and its

* Cuvier. Oss. Foss., tome viii, p. 108, 4th edit., 1836.
† Proceedings of Am. Assoc. Adv. of Science at Cambridge, 1849, p. 352.
‡ Audubon and Bachman. Vivip. Quad. of North America, vol. i, p. 356.

smaller 1·8 inch. This, from its greater size, as well as from the existence of a rudimentary fourth ridge, was probably the fourth tooth in the series.*

The absorption of the fangs, as well as the grinding down of the crown have been carried so far, that it seems quite probable that it actually had been, or was just upon the point of being shed.

No. 3. *Tooth of Megalonyx laqueatus Harlan.*—This tooth, which is represented of its natural size in the adjoining figures, (figs. 1 and 2,) has the grinding surface perfect, but the opposite extremity is broken off. The form of the grinding portion is elongated oval, has an excavation in the middle, which is continuous with a deep emargination on one of the sides of the tooth (fig. 1 *a*); its longest diameter is 1·6 inch, and its transverse 0·8 inch. On the inner face of the tooth there exists a strongly projecting ridge, which extends from the crown to the base. On the ground surface, three distinct portions may be discovered, viz., 1st, a central one (fig. 2 *a*), consisting of ossified pulp, *osteo-dentine*, 2d, a middle portion (*b*) of *dentine*, and 3d, an outer incrustation of *crusta petrosa*, (*c*). The outer edge of the dentinal portion forms a sharp and prominent ridge around the circumference of the crown; the osteo-dentine having been worn away within it and the crusta petrosa on the outside. At the broken end, the pulp cavity is quite large, having walls of only about 0·2 inch in thickness, and is filled with a compact earthy deposit.

Figs. 1, 2. Upper Tooth of Megalonyx—natural size.
Fig. 1, inner face.
Fig. 2, crown.—*a*. Osteo-dentine. *b*. Dentine. *c*. Crusta petrosa.

* With regard to the succession of the teeth of the lower jaw of the Mastodon, the following rule holds good: the 1st and 2d molars have each two transverse ridges; 3d, three ridges with an anterior and posterior basal ridge; 4th, has three ridges with a large posterior tuberculate talon; 5th, resembles the preceding but larger; 6th, supports four ridges and a small talon; 7th, five ridges and a talon. See Owen's Odontography, p. 620; also J. B. S. Jackson, M.D., Proceedings of Bost.

This tooth resembles that of M. Jeffersonii, figured by Cuvier in the Ossemens Fossiles, in the existence of the lateral ridge, but in its proportions does not materially differ from that of M. laqueatus, Harlan, described and figured in his Med. and Phys. Researches.

No. 4. *An ungueal phalanx of Megalonyx.*—This is imperfect and was from a young animal, as is indicated by the fact the epiphysis forming the articulating surface was not cöossified with the body of the bone, and has been detached. (Fig. 3.) Its general resemblance to the corresponding part of one of the Carnivora is sufficiently strong to render excusable the error of President Jefferson, who referred some remains of Megalonyx to this group of animals.

3.

Ungueal phalanx of Megalonyx. Two-thirds natural size.

An ungueal phalanx of Megalonyx is distinguished from that of either Mylodon or Megatherium, by its greater lateral compression, by its more trenchant upper edge, as well as by the absence of a marked flattening or indentation of this last near the point.* It does not appear that the osteology of the foot of Megalonyx has as yet been much more definitely made out than is its dentition.

The specimen here described differs in its proportions from those of which I have been able to find any figures, it being much higher in proportion to its length, allowance being made for the absence of the articulating epiphysis. Its upper edge is quite regularly curved, rounded near the base, but the half near the apex is trenchant. The point of the bone is depressed, and is separated from the tuberosity by an obtuse angular notch. The under edge of the bone is rounded near the apex, but becomes

Soc. Nat. Hist., vol. ii, pp. 60 and 140. Dr. Jackson has shown by actual examination that the molar tooth described by Prof. Owen as replacing the first and second milk teeth, and developed in the jaw beneath them in Mastodon angustidens, does not exist in the Mastodon giganteum.

* Owen's Memoir on the Mylodon, p. 106.

flattened and is divided by a prominent ridge, which forming the base of the tuberosity in front, becomes gradually thicker and stronger as it merges into the latter. Laterally near the point and at the base are numerous vascular channels and openings; one orifice of much greater size than the rest, exists on each side just above the tuberosity, and from it several deeply impressed channels extend towards the extremity of the bone. The tuberosity projects from each side of the bone, the upper surface of this projection being excavated into a deep and narrow channel.

In consequence of the absence of a part of this bone, the proportional measurements of the whole cannot be given. Its greatest height from the tuberosity vertically upwards is 3 inches, its greatest thickness is one inch; from the apex to the middle of its greatest vertical diameter 3·5 inches.

Bibliography of the genus Megalonyx:—

Jefferson, President. Memoir on the discovery of certain quadrupeds of the clawed kind, in the western parts of Virginia: Am. Philosoph. Trans., 1st series, vol. iv, p. 246.

Wistar, Caspar, Dr. Description of the bones deposited by President Jefferson in the Museum of the Society. With plates. Trans. Am. Philos. Soc., 1st series, vol. iv, p. 526.

Cuvier. Ossemens. Fossiles. Tom. viii, p. 304. Pl. 216. Fourth edition. 1836.

Harlan, Richard. Medical and Phys. Researches, pp. 319, 271, 331.

" American Jour. Science, vol. xliii, p. 141; vol. xliv, p. 69; xlv, p. 209.

" Journal Acad. Nat. Sciences, vol. vi, p. 269. This paper contains a description of numerous parts of the skeleton.

Troost, —. Remains of Megalonyx in Tennessee. Trans. Geolog. Soc. Penn., vol. i, p. 144.

Owen, Richard. Memoir on the Mylodon. See his numerous comparisons of Megatheroid animals. Also Conspectus of families, genera and species of this group. p. 168.

" Letter to the editors on Dr. Harlan's notice of new fossil Mammalia, Am. Jour. Sci., vol. xliv, p. 341.

" Odontography, p. 333, pl. 80, fig. 7.

" Fossil Mammalia—Zoology of the Beagle. Pt. I. pp. 63, 99. Pl. xxix.

Dekay. Nat. Hist. N. Y. Pt. I. Zoology of Mammalia, p. 99.

Blainville. Recherches sur l'ancienneté des Edentés terrestres au surface de la terre. Comptes Rendus, Jan. 21st, 1839, pp. 69, 139.

" Osteographie. Fascic. Gravigrades.

Lund, Dr. Extrait d'une lettre de M. Lunde ecritée a Lagoa Santa, (Brezil.) Comptes Rendus—Seance, Avril 15, 1839, p. 570.

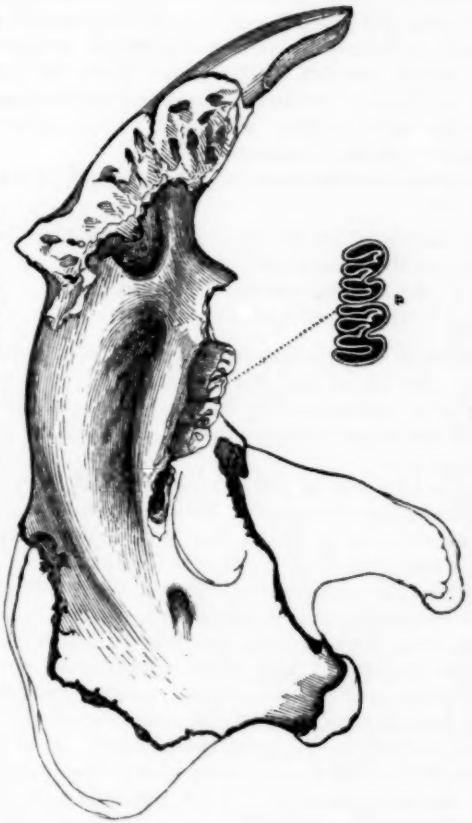
Cooper, William. Annals Lyceum Nat. Hist. N. York, vol. iii, p. 167. This contains an enumeration of all the bones of Megalonyx discovered previous to that date (1833), with accurate anatomical observations.

Am. Monthly Magazine, vol. i, p. 157.

Penny Cyclopedia. Article Megatheridæ.

Doellinger. Spix and Martius—Reise in Brazil, Band. II, p. 5.

Lund, Dr. Blik paa Brasilens, &c. View of the Fauna of Brazil prior to the last geological revolution. Quarto. Kjöbenhavn, 1838, p. 21.



Right Lower Jaw of C. fiber, americanus. Natural size.

No. 5. *Lower Jaw of a Beaver.*—This is the jaw of the right side, (fig. 4,) is deficient in a portion of the coronoid process which is broken obliquely across from the condyle to near its base in front; a large portion of the "angle" of the bone is likewise destroyed, and the first and fourth molar teeth are lost. In its general

conformation it corresponds very nearly with that of a specimen of a common beaver (Castor fiber, americanus), from the neighborhood of Moose-head Lake, except that the impressions for the attachments of the temporal and masseter muscles are more strongly marked in the fossil than in the recent specimen. The form of the condyle is somewhat different in the two; that of the fossil specimen being longer in its antero-posterior diameter and resting on a much broader neck; the whole jaw when viewed from above is also more curved, having the form of an italic *f* more strongly marked.

The second and third molars alone exist, and on close comparison present some peculiarities not found in the recent jaw. The anterior fold of enamel in each tooth which is directed across nearly the whole breadth of the crown from the inner to the outer edge, is slightly involuted (fig. 4 *a*,) at the point where it approaches the outer surface, while that of the recent specimen forms a simple rounded termination.

The comparative dimensions of the fossil and recent specimens are as follows:

Length from tip of incisor to middle of condyle,	3·9 inches.
The same in the recent specimen, . . .	3·5 "
Length of the alveolar process for the molars, .	1·5 "
The same in the recent specimen, . . .	1·3 "

No. 6. This is an alveolar portion only, of a left lower jaw, and contains the 2d, 3d and 4th molars, which gradually become smaller from the second to the fourth. The teeth of this specimen present the same complication of the folds of enamel as in the preceding one.

No. 7. Is a fragment of the left incisor tooth of a beaver, but both extremities are broken off. In its dimensions it corresponds with the same tooth in No. 5, but is of much darker color and appears to have come from a different locality.

Remarks.—The differences between the teeth of the fossil and recent specimens above referred to, would, in the minds of many naturalists, be sufficient grounds for the establishment of an additional species. I have made comparisons with only two recent specimens, and do not consider myself justifiable in forming a new species, until by a careful examination of several jaws, the limit of natural variations be determined. It is not improbable that the above differences come within that natural limit, or may be a sexual peculiarity. It is certainly a matter of some interest and importance to determine if the fossil and recent species are identical.

No. 8. *Castoroides Ohioensis, Foster.*—The most interesting specimen from the Memphis collection is a large fragment of the right half of the lower jaw of this recently discovered species, a species not only interesting for some of its osteological peculiari-

ties, but for the fact of its being the most gigantic member of the order of Rodents hitherto discovered, whether recent or fossil.*

The present fragment is 7·3 inches in length, though the condyle, coronoid process, "angle" and the whole of the under portion of the jaw have been broken off—a portion of the notch (sigmoid) between the condyle and coronoid process remains. The four molar teeth with their alveolar dependencies are entire, and a large fragment of an incisor tooth is still preserved lodged in its partly destroyed alveolus. The jaw is larger and somewhat more massive that the one described by Mr. Foster, but in other respects does not appear to differ materially from it. An approximation to the proportional dimensions of the three jaws which have been noticed may be deduced from the following measurements.

Length of the grinding surface of the molars in

The specimen from New York,	2·7½	inches.
" " " Ohio,	2·8	"
" " " Memphis,	3·1	"

In some other measurements the Memphis specimen exceeds the preceding ones in the same proportion.

5.

Molar teeth of Castoroides Ohioensis, right side of lower jaw,—natural size.

The grinding surface of the molar teeth taken together is somewhat concave in the direction of its length. The anterior tooth rises nearly three-fourths of an inch above the alveolus, the second and third sink nearly to its level, but the fourth is a little more elevated. Each tooth consists of a series of elongated elliptical plates or laminæ of enamel which include the dentinal portion; they are directed obliquely across the crown, and cemented together by a layer of crusta petrosa. The front tooth (fig. 5 *a*) which is the largest, has four laminæ, the first quite small and the third the longest and the most oblique. On the outer face there is a deep groove between the third and fourth plates, and on the inside one between the first and second, another between the second and third, and a very indistinct one between the third and fourth. The second and third grinders have but three laminæ, and their grinding surface has the outline of an hour glass or a figure 8, in consequence of the existence of but a single groove on the outer and on the inner face. In both of these teeth the first and third laminæ are parallel to each other, but the second makes an angle with them, so as to touch the first on the outside, and the third on the inside of the

* This species was first recognized and described by Mr. J. W. Foster in Am. Jour. Sci., vol. xxxi, p. 80, also in the second Report of the Geological Survey of Ohio, p. 81. A cranium nearly entire was subsequently discovered in Clyde, N. Y., and was described and figured in the Boston Journal Nat. History, vol. v, p. 385.

tooth. The outer groove is situated between the second and third plates and the inner between the second and first, but in consequence of the obliquity of the third plate, are nearly opposite. The fourth tooth is the smallest, the laminæ are all nearly parallel to each other and the lateral grooves are much less deep than in the preceding teeth.

It does not appear from any examination which I have made of the fractured teeth, that the different laminæ are united together at their bases by a continuous layer of enamel passing from one plate to the other, as is the case in the teeth of the elephant. Each tooth appears to be made up of a series of flattened dentinal columns invested with enamel and simply cemented together by crusta petrosa.

The incisor tooth in a transverse section is of a triangular form, with rounded angles; its inner face smooth and concave, its anterior convex and fluted with well marked parallel grooves, and its posterior convex and smooth. The double curvature of this tooth is quite remarkable; when viewed laterally its curve is that of the segment of a circle; when viewed from below it has a curvature in a plane at right angles to the preceding, which curve as is shown very distinctly in the cast of Mr. Foster's specimen is in the form of an *f*, as is the case in the beaver and many other Rodents. If both of these curves were continued they would produce a spiral. It is well known that the incisor teeth of Rodents are constantly wearing away at the apex, and are as constantly replaced at the base, so that if we would suppose the growth continued through life, and that no abrasion took place, there would be eventually produced a spiral of several revolutions in the form of a cork-screw. We have an approximation to this in Rodents which have lost one of their incisors, and in whom the opposite one no longer worn off, has continued to increase in length sometimes forming more than one revolution.*

The remains of the Castoroides though they have seldom been found, have nevertheless as already stated, a wide geographical distribution, having been discovered in New York, Ohio, Tennessee and Louisiana, and in all these localities except New York, have been associated with the remains of the Mastodon; and Mr. Hall refers the deposit in which the New York specimen was found to the same period as the deposits in which the Mastodon has been discovered in the neighboring portions of that state.†

It is also interesting to notice the existence of the remains of Castor and Castoroides in the same localities, one of which continues to the present period, and the other, the gigantic representative of the Rodents, has disappeared with the corresponding one of the Pachyderms.

* See Catalogue of Cabinet of Bost. Soc. Med. Improvement, specimens 537 and 538.

† Notice of the Geological position, and an anatomical description of the cranium of Castoroides Ohioensis.—By James Hall, Esq., and Dr. J. Wyman. Boston Journal of Nat. Hist., vol. v, p. 385.

Art. IX.—*On the Geological Structure of Keweenaw Point;* by Dr. C. T. Jackson, U. S. Geologist.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 288.)

This remarkable promontory extends from the south side of Lake Superior nearly into the middle of the Lake, from 46° 40′ to 47° 29′ north latitude, and is comprised between 87° 55′ and 89° 30′ west longitude. Its general direction is to the E.N.E., in the line of the trend of the great dikes or masses of Trap rocks which form its central ridges.

The surface of the country is broken and rolling, and some of the hills attain an elevation of nearly 900 feet above the lake level. Although but few species of rocks exist on this promontory, they present phenomena of remarkable scientific and practical interest. On the immediate coast, excepting at a few points, the first rocks that meet the eye of the geologist are a coarse conglomerate, made up of large rounded and smooth pebbles of red porphyry quartz, altered slate and sandstone, masses of epidote rock, syenite and hard greenstone trap, mostly of the porphyritic variety, and regular strata of fine grained red and grey or mottled sandstone, devoid of any fossil contents.

The direction of the strata of sandstone and conglomerate is parallel to the line of uplift of the trap rocks, or E.N.E., W.S.W. Its dip is toward the W.N.W., at various angles, being greatest near the trap rocks, which come between their strata and divide the great masses of sandstone throughout the whole length of the promontory. The strata remote from the trap on Keweenaw Bay, and the opposite side of the point, at the portage, are horizontal or but slightly waving, while near the trap rocks the dip of the strata is generally as high as 30°, and sometimes more. The conglomerate rock is limited to the borders of the trap range, and is of the same geological age as the finer grained sandstones, and alternates with them.

At the line of junction of the trap rocks and sandstones, the sandstone and trap are interfused, producing that singular and very important metamorphic rock amygdaloid, a rock closely resembling the vesicular lava of volcanoes, but having its cavities filled with a great variety of curious and interesting minerals.

In the memoir published by Mr. Alger and myself on the mineralogy and geology of Nova Scotia, in the American Journal of Science, vols. xiv, xv, 1828, will be found an account of the origin of amygdaloidal rocks, like those of Keweenaw Point, and it may not be uninteresting to compare the trappean ranges on Lake Superior with those of Nova Scotia. On inspection of the map it will be seen that the great trappean band on Keweenaw

Point is parallel with that on the borders of the Bay of Fundy in Nova Scotia, and it will be further noticed on examination of the geology of these distant regions, the conditions of the rocks are similar, if not identical. The trap of Nova Scotia, like that on Lake Superior, protrudes from below the red sandstone, supposed to be the new red, and passes between the strata in the line of least resistance. Amygdaloid, with species of minerals similar to those of Lake Superior, excepting Prehnite, which is rarely found in Nova Scotia, exist also at the line of junction of the trap rocks and sandstones of Nova Scotia. Native copper occurs in the amygdaloid of both places, but is more commonly found in the trap tuff of Nova Scotia, while it occurs more abundantly in the amygdaloid of Lake Superior. Heulandite is rare in the Lake Superior trap rocks, while it is extremely abundant in Nova Scotia, but the other minerals are of the same species in both places.

It will be observed on examination of the geological maps, that the same gentle crescentic curving of the trap bands towards the northwest was noticed in both countries, a fact also recorded by Dr. Percival and Prof. Rogers, in their reports on the geology of Connecticut and New Jersey.

General geological laws seem to have prevailed in all the regions where trap rocks have burst through sandstone, the effects of heat being recognizable, and proportional to the relative masses of intruded rocks.

It cannot fail to strike every geologist familiar with rocks of igneous origin, and their effects on sedimentary strata, that the history of the origin of trap rocks is indelibly recorded, and that they are really lavas that have risen from the interior of the globe through fractures in its crust, taking the line of least resistance by passing between the strata.

By the influence of heat the sedimentary strata were interfused with the igneous rocks, and it is a singular fact that amygdaloid is most abundantly produced by the action of trap rocks on sandstone, and that copper is the most usual metal found in the fissures, amygdules, and pockets of the resulting amygdaloid.

True workable veins of native copper in this class of rocks had not been described, so far as I know, anterior to my researches on Lake Superior, and it was regarded as contrary to all experience that this metal should thus occur in quantities sufficient for profitable mining. The only locality where native copper has been mined to any extent, is in Siberia, but the metal is not in trap.

Having satisfied myself of the fact that adequate quantities of the metal did exist in veins in the amygdaloid trap of Lake Superior, I ventured to recommend the opening of mines on Keweenaw Point, on and near Eagle River, and the result has proved that native copper veins can be profitably wrought. I mention

this fact now in order to recall to your minds the objections that were made to my views on this subject at our meeting in New Haven, in 1845. The predictions I then made are now fully verified.

Nature of the Veins in the Trap rocks.—There are two classes of veins known to miners on Lake Superior, viz.: 1st. Those running with the "country," or parallel to the course of stratified rocks through which the trap rocks pass—veins that are sometimes called beds, or interstratified masses. And 2nd. Those which cross the "country," or cut transversely at various angles the line of direction of the strata.

These last are called true veins, and are the only ones on which miners have thus far placed reliance as to their continuing rich to any considerable depth. I do not regard the question as fully settled by experience in this district, that mining should be confined to the transverse veins, for there is reason to believe that both classes of veins are of the same origin, and no facts have yet been adduced to prove that veins running with the "country" cannot be advantageously wrought. On the contrary, it is known that large quantities of native copper are raised from this class of veins on the Ontonagon River, and it is probable that some on Isle Royale will ultimately prove valuable. A few good practical experiments in mining will settle this mooted point in practical geology. It is obvious, since the trap rocks are not really stratified, that this class of veins cannot be correctly denominated interstratified, though they may be imbedded.

The first class of veins run, as will be understood by what I have previously said, nearly E.N.E., W.S.W., varying with the flexures of the line of junction of the trap and sandstone, and are included between the two rocks in amygdaloid or in epidote, this mineral being the most usual gangue or matrix of the copper. Regular walls of solid copper of some inches in thickness, have been observed in one of the new mines opened in the Ontonagon River, and sheets of considerable size have been found in the east and west veins on Isle Royale.

Mining operations are now in progress to test the permanency of these veins; we shall know in a year or two the results.

The second class or tranverse veins run generally in a course N. 26° to 30° W., S. 26° to 30° E, and consequently cut across the line of direction of the trap rocks and adjacent strata. They are especially rich in the amygdaloidal trap, and thus far have not been profitably worked beyond its limits. In the hard trap rock they are pinched or become narrow, thin plates of metallic copper filling these seams in the trap. The "veinstone" contains the following species of minerals: prehnite, calc spar, laumonite, leonhardite, quartz, datholite, chabasite, mesotype, apophyllite, feldspar, analcime, and wollastonite.

The most common veinstone is prehnite, which occurs in regular symmetrical veins, the prehnite encrusting the sides of the fissures and closing in the middle of it by crystallized botryoidal surfaces. At the surface these veins are rarely more than six inches in width and containing only minute scales of metallic copper, the presence of which in decomposed veins is most readily detected by spots of green carbonate of copper, derived from exposure of the metal to the air and water. These narrow and poor veins of prehnite enrich in copper as they descend into the rock, until at last the prehnite gives way to copper and its space is entirely occupied by it, a thick vein of solid copper filling the fissure, while the prehnite was either absorbed by the rock, or the condition of the rock was such that it could not be formed.

At the Cliff Mine of the Boston and Pittsburg Mining Company, the vein at the top of the cliff consisted of prehnite, containing only minute scales of copper, and was only six inches wide, but it was found on descending that this vein widened, about two hundred feet lower down, to eighteen inches, and lower still it had widened to two feet, and was charged with from five to thirty per cent. of metallic copper, and some particles of silver. The average yield of a large sample of the vein at the surface was found to be $5\frac{6}{10}$th per cent. of copper, and it was estimated that the ore could be practically "bucked" or picked up to 15 per cent.

The width of the vein was estimated to be three feet at the base of the hill, where it was still concealed from view by the soil. On driving a level into the cliff and one at the base of the hill, the vein was proved to be much richer than at the surface, and on sinking a shaft to the depth of 226 feet below the base of the hill, it exposed sheets of copper varying in thickness from a few inches to three feet. These masses of copper filled the vein, and the prehnite and other zeolitic minerals disappeared. By carrying forward levels at the proper points, sixty feet below each other, and by stoping out the backs of the levels, large flattened ellipsoidal masses of copper were exposed, and removed by heavy blasts of gunpowder. These masses were then cut up by mortising out channels through them by means of steel chisels, driven by a heavy sledge hammer.

Some idea may be formed of the rapid increase in richness of this lode by comparing the poor prehnite vein at the top of the hill with the ponderous masses of pure copper that are now cut up in the mine below. One mass of pure copper extracted while I was on the survey, weighed eighty tons, and other masses probably of equal magnitude were in process of being uncovered.

Taking into account the height of the cliff in which the vein is seen, and the depth of the shafts at its base, we have the vein proved 526 feet deep, and thus far it has been steadily enriching, and has surpassed the most sanguine expectations of all the miners and geologists who had examined it.

Already this mine sends to market nearly a thousand tons of copper ore per annum, the ore being estimated to contain sixty per cent. of pure copper after it is cleansed of the adhering rock. This mine, it is understood, has paid for itself and made a dividend of ten dollars per share to its owners.

It is highly probable that other mines on Keweenaw Point, if wrought with the same energy and skill, would prove equally valuable, but thus far no mining equivalent to that of the Boston and Pittsburg Mining Company has been attempted, and it is difficult to find a miner so competent to the task as Capt. Jennings, the Cornish miner, who has had charge of this remarkable mine. I exhibit to you a profile and plan of the mine, in which all the excavations are fully delineated.

Among other promising mines are the North American, the Copper Falls, the Northwest, and the Phenix, all of which have been sufficiently proved to warrant the belief that they can be advantageously wrought, but still it must be remembered that even in the best known mineral districts, mines frequently fail to prove profitable from causes that are not at once foreseen. The North American Company's mines are situated very near the Cliff mine, on the west branch of Eagle River, and are now wrought with energy, and give promise of success nearly equal to that of the Cliff mine before described. The veins are similar in their nature and in their contents, so that I need not describe them.

The Copper Falls mines have been opened to a considerable extent, and from one of the veins a single mass of copper was taken that weighed eight tons. It was sawed into pieces and sent to market. I exhibit to the section a specimen sawed from this mass. It is perfectly pure copper, and as dense as the purest hammered copper of commerce, showing its perfect fineness. There is a considerable proportion of native silver mixed with the copper of this mine, and in the green veinstone, a specimen of which I lay before you. Silver is found also in most of the copper mines of the lake, and frequently in sufficient quantities to be of commercial value. It is most curiously united with the copper, and in some of the pieces I lay before you, the metallic copper is actually porphyritic with masses of silver, and yet the silver is absolutely pure, and the copper is also pure, there being no alloying or chemical union, but a mere metallic cementation at the line of contact. This phenomenon is seen in all the localities on the lake where native copper and silver occur together, and this state of the metals must have arisen from a common cause acting in every one of the veins. It is not capable of being explained in the present state of chemical and geological knowledge, and is a subject for experimental research. The solution of this question will lead to an explanation of the origin of the native copper and silver veins, the rationale of which we have not yet reached.

All the experiments I have devised and executed, to discover the cause of the separation of the copper and silver, as seen in these specimens, have given negative results. The experiments were made on fused alloys of silver and copper. The metals did not separate by galvanic agency. Little has yet been done towards extensive working of the Northwest Company's copper mine. It is situated a few miles from Eagle Harbor, and several rich veins of native copper, with some native silver, have been discovered and wrought to a small depth. The want of confidence in this new kind of mining prevents the investment of sufficient capital and the employment of a sufficient mining force to work the mines. I am confident, that, with capital and skill, this company's mine might soon be rendered profitable.

The old Lake Superior Company, the first organized for mining on Lake Superior, was unsuccessful in its first operations from several causes, among which the want of miners capable of carrying on the work in a proper manner was the chief; and it should be remembered that mining for native copper was, at that time, a new business to both English and American miners. Numerous changes were made and many new shafts were sunk, but no regular preconceived plan was ever carried out, and hence the mines are in a neglected state. Much allowance should be made for the newness of the enterprise, the wilderness state of the country, and want of skill in the miners hastily collected from districts wholly unlike the one they were sent to explore. There was also an erroneous opinion prevalent among many of the original stockholders that mining could be made profitable from the outset,—a most fallacious idea. The company soon closed up its mining operations, and I have heard that a new organization has been since adopted, and it is hoped, if mining operations are again begun, a regular system will be pursued, modelled after the plan of the Boston and Pittsburg Company's workings. The Lake Superior or Phenix Company's veins are rich in native copper and silver, and although the leader or prehnite vein is but a few inches wide, it will doubtless lead to a solid copper vein, like those heretofore described. Masses of pure copper, of large size, weighing some thousands of pounds, were obtained from an ancient ravine or excavation that had been worn out by the river running over the vein, and large pieces of silver were also found. These show the contents of the lode in the true vein. Most of the work heretofore executed at this mine has been done in the western wall of the vein and not in the vein itself. To the company owning the Lake Superior mine is due the credit of the earliest mining enterprise on the Lake, and those who have followed after them should remember that they opened the way and introduced the business of mining into the then unbroken wilderness of Lake Superior.

It is still a question among geologists and miners whether veins were filled by igneous injection or sublimation, or by aqueous and galvanic deposition. This question is one of very great scientific and practical interest, and is exceedingly difficult to answer so far as relates to the native copper and native silver of Lake Superior.

The objections to the igneous origin of native copper are, 1st, that the metal bears the imprint of crystals of prehnite, as seen in the specimen I lay before the section, and we cannot account for the fact that this zeolite was not rendered anhydrous by the molten copper. 2dly, that if the copper was melted, since its fusing point is much higher than that of silver, that the silver is not alloyed with the copper, but is separate from even a trace of it in chemical combination, though small particles and large lumps of silver are mixed and united with the metallic copper.

These objections are equally strong against the theory of sublimation of the copper, and since silver is not volatile at the highest temperature of our furnaces, we could not account for the presence of that metal by a simultaneous sublimation of the metals.

Against the theory of its aqueous deposition, or its origin from any solution of copper, it may be urged that if the metal was in chemical solution, no material capable of causing its decomposition with the deposition of the copper in a metallic state exists in the vein, and no salt, if any supposed acid solvent, which would result from the decomposition of its combination, exists in the vein. Again, it would be impossible for the chasm to contain a sufficiency of any copper solution, however concentrated, to produce the solid metallic copper filling the fissure, for, as before observed, the masses of copper are from a foot to three feet in thickness, and occupy the whole space of the sundered rock.

Galvanic segregation it has been supposed would explain the origin of these copper veins. But we may ask, from what was the copper segregated? It is impossible for galvanism to create the metal from the ingredients of trap rocks, or sandstone; and we can hardly imagine any arrangement of the rocks that would produce a galvanic battery with its poles so arranged as to effect the deposition of a vein of solid copper two or three feet in thickness.

It is well known that the trap rocks are magnetic, and that they possess polarity at the surfaces of disjunction. This has been fully substantiated by the researches of Dr. Locke and others on the Lake Superior mineral lands, but this magnetism is obviously the effect of the earth's inductive magnetism exerted on the very large proportion of magnetic iron ore entering into the composition of the trap rocks, a quantity so large that I have seen pig iron made directly from those rocks by fusion in a blast

furnace, about twelve per cent. of iron being reduced from it; and we know, from the experiments of Dr. Locke, that even fragments of the trap rock are both magnetic and polar. It remains to be proved that there are any *electric* currents in the native copper veins, for such currents are by no means proved by deviations of the magnetic needle, which are doubtless produced by the magnetic polarity of the trap rock itself.

The occurrence of bright scales and perfect crystals of native copper in perfect crystals of prehnite, datholite, calc spar, and quartz, would seem to indicate a simultaneous deposition of the copper and those crystallized minerals including it, or that they were impregnated with native copper by sublimation immediately before the injection of the principal copper vein took place. If we could admit the igneous formation of zeolites, and of calc spar, there would be less difficulty in accounting for the veins by sublimation or injection, or by both methods, but this chemists will not readily admit, for the zeolitic minerals are generally hydrous.

It is also a question whether the native copper in the amygdaloid was derived from the interfused sandstone, or was mechanically brought up with the trap rock. It has been imagined, that since the sandstone is made up of the detritus of more ancient rocks which might have contained copper ores, that the copper ore being deposited with the sand was reduced by the action of the trap. This idea would be plausible, if it could be shown that the sandstone in the vicinity of the trap contained copper in a sufficiency to account for that in the amygdaloid; but such is not the case. It has been said that local deposits of the ore might have taken place in portions of the sandstone strata, and that the trap rocks came up and reduced it. This would be imputing a most remarkable degree of intelligence to the trap rocks, that they should know exactly where the copper ore was deposited, and come up at those places expressly to smelt it! I must confess that I cannot attribute the origin of the copper to any other causes than those which produced the trap rocks themselves, and that the copper came from the molten interior of the earth seems, at least from what we know of igneous agencies, to be most probable. There are veins in the conglomerate rocks which are filled with calcareous spar, containing crystals of copper, some of which will weigh half a pound, and are generally in the rhombic dodecahedral form. One of the calc spar veins at Agate Harbor has yielded masses of copper weighing several hundred pounds.

At Copper Harbor, a large vein of solid black oxyd of copper was found in the conglomerate rock. This ore is not known to exist in any considerable quantity elsewhere. The ore in the vein was fourteen inches wide, and for a short time the mine furnished a good supply of copper ore, yielding about sixty or sev-

enty per cent. of metallic copper. It was soon exhausted, a bed of fine grained sandstone cutting off the copper vein, the calc spar only continuing in the sandstone below. Among the masses of black oxyd of copper brought from the mine at Copper Harbor, Mr. J. E. Teschemacher discovered regular cubic crystals of the ore, crystals which show that the ore is not a mere mechanical mixture of copper smut with earthy matters for a cement, as some have supposed. A pure specimen analyzed in my laboratory yielded 79·86 per cent. of copper.

There are also found at the Copper Harbor mine, chrysocolla, or hydrous green silicate of copper, and the black silicate, which contains a less proportion of water. These ores, we can easily conceive, might be produced by the decomposition of a solution of copper by the action of a hot solution of lime. The black oxyd may have been derived either from a solution, or from igneous sublimation. We know that black oxyd of copper is sublimed from the crater of Vesuvius, and is deposited in fine splendent scales like specular iron ore in the lavas.

Chlorid of copper is very volatile, and is sublimed in the crater of Vesuvius. It is also known to be volatilized in the blast furnace. The experiments of Mr. Frederick W. Davis, at the Point Shirley copper works, have fully demonstrated the fact that a considerable proportion of copper is lost by sublimation from copper ore, containing the chlorid of that metal.

These facts may at some future day serve to explain some of the phenomena relating to the formation of metallic veins. At present there is no part of geological science so little understood as the theory of veins, and on this account I am desirous of calling the attention of the Section to this subject.

With respect to the age of the red sandstone of Lake Superior, I would remark that there have been and still are differences of opinion. No distinct fossils having been found in it, the usual index for fixing the geological age of stratified rocks is wanting.

From the mineralogical character and the geological associations of the rocks, their parallelism to those of Nova Scotia, and their mineral contents, I was led in 1844, to suggest the identity of the two formations, as contemporaneous, and regarded the Lake Superior sandstone as the new red, or at least as of the same age with that of Nova Scotia, New Jersey and Connecticut. This idea I still favor.

During the last year the linear surveyors, who were engaged in subdividing townships on the southern portion of Keweenaw Point, discovered a large protruding mass of Silurian limestone, around which the sandstone strata are horizontal. My assistant was sent to examine this limestone, and states that its strata lines dip about 30°. A fragment of a fossil, probably a Pentamerus, was also found in the limestone. These facts would

seem to prove that the sandstone is above the Silurian limestone, and consequently that it is either the old or the new red. The absence of fossil shells in the sandstone would lead us to conclude that it does not belong to the old red, and consequently we are led back to my original opinion, as published in the American Journal of Science, in 1845, that the Lake Superior sandstone is of a later date, and is probably the new red.

This opinion was also expressed by Monsieur De Verneuil, during his visit to the Lake in 1846, but I do not know from what data his opinion was formed. It has been asserted that the Lake Superior sandstones pass beneath the Silurian rocks, but I do not think the fact has ever been observed.

Isle Royale.—This island is situated on the north side of Lake Superior, in latitude 48° North, longitude 89° West. It is about forty miles in length, and five or six miles wide. It presents a broken and rugged outline on its coast and is deeply indented by long and narrow inlets and bays, all of which are parallel to the ranges of the trap rocks which constitute the ridges traversing the island throughout its length. Several small lakes are also seen lying between the trappean hills and coinciding with their line of bearing.

The general direction of this island is parallel to that of Keweenaw Point, and the trap rocks are of the same geological age and have uplifted the sandstones of the same epoch.

On the southwestern end of the island the fine red sandstone strata are seen near Card's Point, and they extend along the coast of Siskawit Bay to Epidote Cove, forming gently sloping sheets extending out into the lake to a considerable distance. Conglomerate rocks border the coast nearly to Rock Harbor and lie next to the trap. The inland boundary of the sandstone was ascertained by my sub-agents to be parallel to the coast line where it is exposed. About one-fourth the area of the island is sandstone and conglomerate rock. All the rest of it consists of trap, which forms ridges attaining an elevation of from three hundred to five hundred feet above the lake, and extending in a broken line throughout the whole extent of the island. In some places isolated masses of trap rocks form tall towers standing like high chimneys on the hill sides; in others, picturesque islands covered with dark spruce trees are seen jutting out on the coast, or standing like watch towers at the entrance of the harbors.

Isle Royale was better known to the Indians as a good place for catching Siskawit than as a mining region; and it is probable that the name *Menung*, signifying a good place, refers to the fisheries, but it is certain from the "Relacions" of the Jesuit fathers, that they were aware of the existence of an abundance of copper boulders upon its shores.

Numerous explorers had visited Isle Royale anterior to my survey, but mining operations had not been entered upon to any extent on account of the difficulties arising from some official misunderstanding as to permits for leases. Dr. Locke had selected some veins and beds of copper for the Ohio and Isle Royale Company, and explorations were going on to determine the probable value of several veins.

There are two kinds of veins on this island, as before mentioned. The widest are those near Rock Harbor. They are thick beds of solid epidote rock filled with small spiculæ of copper, there being from eight to ten per cent. of the metal in the gangue. These beds dip but slightly from the horizon, rarely more than 15 or 20°, and crop out on the south side of the island a few feet above the surface of the Lake. Beneath the copper-bearing bed of epidote, which is a foot in thickness, is a large bed of barren epidote rock, six feet thick, and very hard. Trap rocks overlie the whole, forming bold precipitous shores. No mining operations have yet proved the extent of these cupriferous epidote rocks, but they are exposed to a sufficient extent to render it probable that they will prove of value.

Another set of true veins occur, cutting the trap rocks nearly at right angles, and traversing the country. These veins are generally narrow, and are filled with datholite, prehnite, and native copper. The datholite is very abundant, and may prove of economical importance either as a flux for copper ores, or as a material suitable for the manufacture of borax. One of the locations of the Ohio and Isle Royale Company was named, by Mr. J. H. Blake, Datholite, on account of the abundance of that mineral in the veins of copper.

At Todd's Harbor, mines have been opened, and a considerable quantity of native copper has been obtained by Mr. McCulloch. Other veins have been opened at Scovill's Point, but as yet none of the veins on the island have been sufficiently proved to authorize the erection of permanent works for mining and smelting. One vein of each kind, opened to a considerable depth, would give much valuable information concerning the permanency of the veins, and determine whether they widen and enrich or not.

It is extremely difficult for any one to decide absolutely on the value of a metalliferous vein, and it is only possible to form an approximate estimate where all the conditions of the problem are capable of being determined, and it is rarely the case that we have any thing more than a superficial view of the contents of a vein. It has been proved by a writer in the French Annales des Mines, that in Germany and France only one-twentieth of the mines surveyed and recommended by the Royal Engineers of mines have paid a profit to the stockholders, hence we should re-

mind persons about to engage in mining adventures that their chances of success are only about five per cent.

When a mine is well proved it generally holds good veins, rarely running out in depth unless the rock changes, and then the vein also generally alters.

How far the native copper of the Lake Superior mines continues in depth is yet unknown, but the veins if they traverse sandstone strata will certainly change in that rock, and experience has thus far shown that the copper diminishes in that portion of the vein which traverses the sandstone. This has been fully proved at the Copper Falls mines, where a bed of sandstone, seventy-two feet in thickness, has changed the character of the lode where the vein passed through it, calc spar filling the chasm and the copper nearly disappearing in the veinstone.

It was hoped that the vein would enrich after it had passed through the sandstone into the nether bed of trap rock, but it was found to be diffused into string veins of little practical importance. Owing to the limited extent of the amygdaloidal trap, the true or transverse veins are not of great length, two thousand feet being perhaps an approximation to their linear extent, though it is possible that some may be longer. The idea of tracing a vein by its course over an extensive tract of country has proved fallacious on Lake Superior, and only the geological character of the country can be relied upon as a tolerably correct guide. The river beds, depressions in the soil, corresponding to the usual direction of the veins, afford the best facilities for finding veins, and by means of the solar compass and magnetic needle, lines of contact of the sandstone and trap may be readily found, and the amygdaloid is formed at those junctions. It was observed in my first visit to the Lake, that the productive copper veins occur where there are the greatest number of alternations of sandstone and trap rocks, as shown by the diagram exhibited to the Section. No less than six alternations of these rocks were observed near Copper Falls and Lake Superior mine in my surveys during the summers of 1844 and 1845. Subsequent researches have confirmed this observation.

From these data we should expect copper veins at the line of contact of the sandstone and trap on Isle Royale, but thus far in only a few places have the rocks been uncovered in the vicinity of the junction—some loose masses of native copper found on the shore of Siskawit Lake and the veins at Datholite Cove being the only facts obtained in confirmation of this opinion.

In the hard columnar and compact trap there is little hope of finding valuable veins, for only narrow and tightly pinched seams of copper have thus far been found in these rocks.

On the Ontonagon river there are several veins of copper that run with the "country." They are now in course of trial, and

it will soon be ascertained whether they can be profitably worked or not. The opinion of a practical miner, on whom I place reliance, is favorable to some of these mines. It was my intention to have examined them myself, this summer, before drawing up my report, but it has been ordered otherwise.

Rich ores of iron have been found in inexhaustible quantities in the district of country extending from the Menomonee River to Dead River. I have not had an opportunity of examining the localities myself, but I had obtained rich specimens of the ore from the Menomonee river, in 1844, through the agency of M. Barbeau, who obtained them from the Indians, and in 1845, the Indian chief who furnished those specimens, guided Mr. Pray to the Iron Mountain near the Menomonee River. During the past summer this locality has been also examined by one of my assistants.

Art. X.—*Analysis of Algerite;* by Richard Crossley.

Read before the Bost. Soc. Natural History, by C. T. Jackson, April 17, 1850.

This mineral having been already described in this Journal for July, 1849, vol. viii, No. 22, renders it unnecessary to say much more on this head. I have in addition, however, to remark that many of the crystals are encrusted with idocrase, and in some instances are penetrated, so much so that it required great caution to secure such portions as were free from that mineral. The crystals being cleared of decomposed parts were broken to coarse fragments, and the honey-yellow pieces reserved for examination.

Before the blowpipe, alone, it readily fuses with intumescence to a white blebby glass: with soda it gives a dirty-white slag: with borax and phosphorus salt it gives a clear bead faintly tinged by iron and leaves a siliceous skeleton. Heated in a closed tube it gives off water which reacts feebly alkaline, and the powder, at first of a light buff color, darkens and assumes a brownish tinge. About 1 gramme of the coarse fragments gave a spec. grav. of 2·78. It is a little harder than calc spar, from 3 to 3·5.

Nearly 2 grammes of the mineral were very finely powdered, intimately mixed and divided into two portions. One was appropriated to the determination of the water and the other for the estimation of the carbonic acid. This latter portion was then *attacked* by a mixture of sulphuric and hydrochloric acids. The usual mode of analysis was afterwards pursued, and there resulted:—

Silica, ...	51·27
Alumina, ...	23·10
Peroxyd of iron, . . .	1·48
Magnesia, ...	5·18
Carbonate of lime, . . .	4·21
Potash, ...	9·97

To ascertain the purity of the silica it was fused with carbonate of soda and was found to contain 1·31 per cent of alumina. A second *attack* by acids would doubtless effectually decompose this mineral. Correcting the silica and alumina and adding the water determined on the first portion, the composition of the selection made will be thus:—

Silica,	49·96
Alumina,	24·41
Peroxyd of iron,	1·48
Magnesia,	5·18
Carbonate of lime,	4·21
Potash,	9·97
Water,	5·06
	100·27

The amount of carbonic acid directly estimated agreeing so nearly with that in the carbonate of lime obtained, evidently shews that the lime is not a constituent of the mineral. Deducting, therefore, the carbonate of lime and reducing the remaining members to per-centage proportions, they will stand thus:—

	Oxygen.		Ratio.
Silica,	52·00	27·01	7
Alumina,	25·42	11·88	3
Peroxyd of iron,	1·54	·47	
Magnesia,	5·39	2·08	1
Potash,	10·38	1·75	
Water,	5·27	4·68	1 or $1\frac{1}{3}$
	100·00		

The above composition is very well represented by the formula,

$$(\dot{M}g, \dot{K})^3\,\ddot{S}i + 3\ddot{A}l\,\ddot{S}i^2 + 3\dot{H}.$$

Boston, April 18, 1850.

ART. XI.—*On the Telluric Bismuth of Virginia;* by Dr. C. T. JACKSON.

I DISCOVERED this ore in May, 1848, among some specimens of native gold given me by Mr. Knowles Taylor. At that time I had not a sufficient quantity of the mineral to enable me to make a complete analysis of it, but having made a blowpipe assay and satisfied myself that it was an ore of Tellurium, I communicated my results to the American Journal of Science and Arts, and my note was published in vol. vi, No. 17, 1848, p. 188.

My only object then was to announce the discovery of Tellurium, and I intended at the earliest moment in my power to procure a larger supply of the ore and to complete my analysis. Subsequently, Mr. Fisher* of Philadelphia made an analysis of

* This Journal, [2] vii, 282.

a specimen which he obtained from the mint, and discovered that the metal which I had supposed to be lead in my cupellation process was bismuth. This fact I am enabled to confirm by my own analysis. Mr. Fisher states that selenium takes the place of sulphur. This is not the case in my specimens, all of which yield sulphur when treated by nitric acid or by the blowpipe, and selenium exists only in minute traces.

Last spring I made a hasty visit to the gold mines of Spottsylvania County, Va., and obtained at Whitehall a few pieces of the tellurium ore. These specimens were in mica slate in nodules, and were incrusted with yellow oxyd of bismuth. The gold found in these specimens is not chemically united with the tellurium ore, but exists in small scales between the folia in its metallic state and varies in proportions from 2 to 5 per cent. The tellurium ore is found incrusting masses of native gold, and the edges of the laminæ of tellurium ore impress the metallic gold with well marked striæ and indentations indicating that the tellurium ore was deposited first in the cavities or veins, and the gold was then deposited upon it. This is the order of deposition in many specimens I have seen.

The tellurium ore is found both in the quartz beds or veins and in the mica slate, and is always mixed with native gold.

Form, thin scales frequently intersecting each other; no regular crystals observed. Occurs in lamellar masses readily cleavable, the laminæ splitting like sulphuret of molybdena, which it much resembles in appearance. It is flexible and not elastic. Sectile and not brittle. Color and lustre like flexible foliated graphite. Its hardness = 1. Lustre splendent metallic. Color of streak like that of lead.

Analysis on one gramme of the picked scales:—

Bismuth, ...	58·80
Tellurium, ...	35·05
Gold, ox. iron and earthy matter, . .	2·70
Sulphur, ...	3·65
	100·20

This gives the formula of Tetradymite, $2BiTe^3 + BiS^3$ = Bismuth 59·6, sulphur 4·5, tellurium 35·9.

The tellurium after it was reduced by sulphurous acid, was attacked by means of carbonate and nitrate of potash by fusion, and the contents of the crucible being dissolved and acidulated by means of nitric acid and treated with nitrate of baryta, did not give a weighable quantity of seleniate of baryta. The selenium therefore exists only in minute proportions and is a mere *trace*.

In addition to the above, I would observe that the yellow oxyd of bismuth occurring investing the nodules of tellurium ore, is not carbonate of bismuth, for it does not effervesce with

acids. Dr. Chilton had observed *carbonate of bismuth* with the gold rock of South Carolina, some time before I found this, and sent me a specimen of it. This ore, (bismutite,) from the gold district of Chesterfield, S. C., has been analyzed by Rammelsberg, (Pogg. Ann., lxxvi, 569, 1849,) who obtained $\dot{B}i$ 90·00, $\dot{C}$ 6·56, $\dot{H}$ 3·44, whence he has deduced the formula $3(\dot{B}i\,\dot{C}+\dot{H})+\dot{B}i\,\dot{H}$, equivalent to $4\dot{B}i, 3\dot{C}, 4\dot{H}$.

ART. XII.—*On a supposed New Mineral Species;* by HENRY WURTZ, of New York.

THIS mineral was found near Cambridge, Mass., at "Milk Row Quarry," the well-known locality of prehnite. It occurs as an incrustation upon the surface of the syenitic rock, coating the sides of fissures, and presenting the appearance of brilliant plates overlying one another like the scales of a fish.

Its color is black; lustre, resinous; streak, dark olive green; structure, distinctly fibrous, somewhat like that of tremolite; feel, soapy. Hardness, about 2; slightly translucent in thin laminæ. The fibres are brittle. No cleavage was found. Under the lens it exhibits white crystalline specks, which the analysis proved to be calcareous spar.

It is easily decomposed with effervescence by hydrochloric acid, which is thereby colored deep green, silica being left behind as a white powder. Its fusibility is about that of natrolite, or 2 on Kobell's scale. It fuses to a dull black opaque globule which is slightly magnetic.

Two determinations of the specific gravity, made upon two different specimens, gave the same number, 2·69, which being about the specific gravity of calcareous spar, no correction due to the 12 to 23 per cent. of this mineral which the analyses indicate, need be made.

Qualitative analysis indicated the presence of carbonic acid, water, lime, soda, silica, oxyd of iron and alumina.

For the quantitative analysis, a portion of the mineral was finely elutriated, and then dried at 212° in a steam-bath until it lost no more weight. Attempts to separate the calc spar by means of very dilute acetic acid were unsuccessful. The acid became immediately colored red by dissolving some of the iron.

When the dark-green powder of this mineral is heated to redness in the air, it assumes upon cooling a red color, indicating peroxydation of the iron. The water determinations were therefore made in small bent tubes, which were sealed up immediately after the expulsion of the water, and the mass thus cooled out of contact with the air. The residue, after the expulsion of the HO, had, in this case, a black color.

The carbonic acid was determined by the well known method of the weighed flask and Ca Cl tube.

The other constituents were determined in the usual manner, by dissolving the mineral in HCl, etc. In making the two following analyses, the most extreme precautions were used to ensure accuracy. Every product of the analysis was reanalyzed after being weighed. Thus, the silica, after being weighed, was fused with carbonate of soda and the Ǟl and F̄e which had been left in it by the HCl separated, weighed, and added to the HCl solution, their weight being deducted from that of the silica. In one case, this weight amounted to half a per cent. of the substance used. Difficulty being found in separating the Ǟl and F̄e, by means of KO, in one experiment the F̄e and Ǟl were weighed together, and the Ǟl calculated by deducting the amount of F̄e afterwards found in the mass.

	I.	II.	Mean.	Oxygen.
S̄i	27·70	27·32	27·51	14·29
Ǟl	10·30	10·17	10·23	4·78
F̄e	27·99	27·55	27·77	6·17
N̄a	1·23	. .	1·23	·32
H̄	8·69	8·73	8·71	7·74
Ca	12·25	12·98	12·61	
C̄	10·32	10·09	10·29	
			98·35	

The first thing to be observed here is that the quantity of C̄ found is just sufficient to form Ca C̄ with the Ca found, 12·61 Ca requiring 9·91 C̄, so that, in all probability, the lime present is all in the form of calc spar.

So far, I had proceeded upon the hypothesis that this mineral contained no F̄e, judging from its deep color and the color of its solution in HCl; knowing also that the best analysts have generally supposed that all the iron contained in minerals which give deep green powders is in the form of F̄e O. This error of which so many examples may be found in mineralogical works, has its origin in the great difficulties always met with in the separation of the two oxyds of iron from one another, and also in the small difference between the equivalents of the two oxyds,—9 per cent. of protoxyd making only 10 per cent. of peroxyd.

The suggestion of a scientific friend that the mineral might still contain both oxyds, led to a renewal of my research.

The stock of elutriated material, originally prepared, being exhausted, it was necessary to repeat the analysis from the beginning on another specimen, which was accordingly done, in the same manner as previously, with the exception that the F̄e was determined according to the method of Fuchs, that is, by weighing a piece of bright copper before and after its immersion in the HCl solution of a weighed quantity of the mineral, contained

in a stoppered bottle, which was kept, during the operation, in boiling water. The ratio of the loss sustained by the copper to the Fe present, is that of their equivalents.

	I.	II.	Oxygen.	
$\ddot{S}i$	30·86	30·93	16·05	16·05
$\ddot{A}l$	3·92	. .	1·83	7·89
Fe	20·25	20·17	6·06	
Fe	21·97	. .	4·88	5·30
Na	1·62	. .	·42	
Ca C	12·77	. .		
H	8·94	. .	7·95	7·95
	100·33			

The ratio for the oxygen of the protoxyds, peroxyds, silica and water, $5{\cdot}30 : 7{\cdot}89 : 16{\cdot}05 : 7{\cdot}95 = 1 : 1{\cdot}49 : 3{\cdot}03 : 1{\cdot}50$ or quite closely $1 : 1\frac{1}{2} : 3 : 1\frac{1}{2}$. This gives the general formula

$$\dot{R}^2\,\ddot{S}i + \dot{R}\,\ddot{S}i + 3\dot{H}$$

or the special formula,

(1.) $$(\dot{F}e_{\frac{5}{6}\frac{8}{3}\frac{1}{1}} + \dot{N}a_{\frac{5}{6}\frac{0}{3}\frac{1}{1}})^2\,\ddot{S}i + (\ddot{A}l_{\frac{1}{4}\frac{9}{3}} + \dot{F}e_{\frac{2}{4}\frac{3}{3}})\ddot{S}i + 3\dot{H}.$$

An attempt to bring the first two analyses under this formula gave the following result. If we suppose that a portion of the iron, whose oxygen, when in the form of Fe, is equal to one-half of the oxygen of the Al present, was actually present in the form of Fe, the following numbers present themselves:—

	Mean.	Oxygen.	
$\ddot{S}i$	27·51	14·29	14·29
$\ddot{A}l$	10·23	4·78	7·17
Fe	7·97	2·39	
Fe	20·60	4·58	4·90
Na	1·23	·32	
H	8·71	7·74	7·74
Ca C	22·90		
	99·15		

The ratio $4{\cdot}90 : 7{\cdot}17 : 14{\cdot}29 : 7{\cdot}74 = 1 : 1{\cdot}46 : 2{\cdot}92 : 1{\cdot}58$ or nearly $1 : 1\frac{1}{2} : 3 : 1\frac{1}{2}$, as before.

Thus, upon this hypothesis, the general formula $\dot{R}^2\,\ddot{S}i + \dot{R}\,\ddot{S}i + 3\dot{H}$ represents these analyses also very well. The special formula for this variety would be

(2.) $$(\dot{F}e_{\frac{1}{1}\frac{4}{5}} + \dot{N}a_{\frac{1}{1}\frac{1}{5}})^2\,\ddot{S}i + (\ddot{A}l_{\frac{2}{3}} + \dot{F}e_{\frac{1}{3}})\ddot{S}i + 3\dot{H}\ (\text{or } 3\tfrac{1}{4}\dot{H}).$$

The composition is near that of groppite, for which Rammelsberg writes the formula $\dot{R}^2\,\ddot{S}i + \dot{R}\,\ddot{S}i + 2\dot{H}$. But groppite is a rose-red species, containing little iron and lime and much magnesia with potash, and moreover Svanberg's formula for it is very different. There is sufficient reason therefore, for believing the species here described as distinct, and I therefore propose for it the name *Melanolite*.

As the recent investigations of Mr. J. D. Dana, published in the American Journal of Science for March, 1850, have given increased

interest to the subject of atomic volume among minerals, I have here calculated the atomic volume of these varieties.

	(1.)			(2.)	
$\dot{S}i^2$	=	1154·62	$\dot{S}i^2$	=	1154·62
$\dot{A}l\frac{1}{4}\frac{0}{3}$	=	149·26	$\dot{A}l\frac{2}{3}$	=	427·87
$\dot{F}e\frac{2}{4}\frac{3}{3}$	=	767·45	$\dot{F}e\frac{1}{1}$	=	333·33
$\dot{F}el\frac{3}{6}\frac{3}{3}\frac{1}{1}$	=	828·68	$\dot{F}el\frac{6}{7}\frac{5}{5}$	=	840·00
$\dot{N}a\frac{1}{6}\frac{0}{3}\frac{0}{1}$	=	61·36	$\dot{N}a\frac{1}{7}\frac{0}{5}$	=	51·63
$\dot{H}^3$	=	337·50	$\dot{H}^{3\frac{1}{4}}$	=	365·62
		3298·87			3173·07

These two numbers, which are the atomic weights of the two varieties, divided by the specific gravity 2·69, give for (1), the atomic volume 1226·35, and for (2), 1180·, the difference between which is about $\frac{1}{35}$th. If we go farther, and divide these numbers by the number of atoms of the elements in each variety, we shall obtain the C atomic volume, as this term is used by Mr. Dana. In one case we get 53·32, and in the other 50·21. If reference is now made to the tables of atomic volumes given by Mr. Dana in the American Journal for March, 1850, p. 242, it will be seen that these numbers are nearly identical with those given by him for three varieties of talc, a mineral which the one now under consideration resembles in many important characters. On the contrary, chlorite, a mineral to which this one is so intimately connected as to have been mistaken for it by an eminent mineralogist, gives altogether a different number. I have calculated the C atomic volume of chlorite from one of Kobell's analyses which gives the formula

$$\dot{S}i^2+\dot{A}l+\dot{M}g^{4\frac{1}{2}}+\dot{F}e^{\frac{1}{2}}+\dot{H}^4$$

and obtained 43·6. The hisingerite from Ridderhyttan also resembles this mineral very closely. Its formula, according to Hisinger and Kobell, is $\dot{F}e\,\dot{S}i+\dot{F}e\,\dot{S}i+6\dot{H}$; and specific gravity 3·045. Its ordinary atomic volume is 1077·05, and its C atomic volume 39·9, thus approaching that of chlorite, instead of that of this mineral.

Laboratory of the Coll. of Phys., Crosby st., New York, April 1, 1850.

ART. XIII.—*The Erratic Phenomena about Lake Superior;* by Prof. AGASSIZ.

[WE cannot better notice the very valuable and interesting work of Prof. Agassiz and his associates upon the Lake Superior Region,* than by citing one of its chapters. The following observations on the Erratic Phenomena of the region constitute Chapter X, of the work, pages 395–416.]

* The title of the volume and its contents are mentioned in our last number, p. 455.

So much has been said and written within the last fifteen years, upon the dispersion of erratic boulders and drift, both in Europe and America, that I should not venture to introduce this subject again, if I were not conscious of having essential additions to present to those interested in the investigation of these subjects.

It will be remarked by all who have followed the discussions respecting the transportation of loose materials over great distances from the spot where they occurred primitively, that the most minute and the most careful investigations have been made by those geologists who have attempted to establish a new theory of their transportation by the agency of ice.

The part of those who claim currents as the cause of this transportation has been more generally negative, inasmuch as, satisfied with their views, they have generally been contented simply to deny the new theory and its consequences, rather than investigate anew the field upon which they had founded their opinions. Without being taxed with partiality, I may, at the outset, insist upon this difference in the part taken by the two contending parties. For since the publication of Sefstroem's paper upon the drift of Sweden, in which very valuable information is given respecting the phenomena observed in that peninsula, and the additional data furnished by de Verneuil and Murchison upon the same country and the plains of Russia, the classical ground for erratic phenomena has been left almost untouched by all except the advocates of the glacial theory. I need only refer to the investigations of M. de Charpentier, Escher, Von Derlinth and Studer, and more particularly to those extensive and most minute researches of Prof. Guyot in Switzerland, without speaking of my own and some contributions from visitors, as the Martins, James Forbes and others, to justify my assertion that no important fact respecting the loose materials spread all over Switzerland has been added by the advocates of currents since the days of Saussure, de Lüc, Escher and Von Buch; whilst Prof. Guyot has most conclusively shown that the different erratic basins in Switzerland are not only distinct from each other, as was already known before, but that in each the loose materials are arranged in well-determined regular order, showing precise relations to the centres of distribution, from which these materials originated; an arrangement which agrees in every particular with the arrangement of loose fragments upon the surface of any glacier, but which no cause acting convulsively could have produced.*

* A comparison of the maps showing the arrangement of the moraines upon the glacier of the Aar in my *Système Glaciaire*, with the map which Prof. Guyot is about to publish of the distribution of the erratic boulders in Switzerland, will show more fully the identity of the two phenomena.

The results of these investigations are plainly that the boulders found at a distance from the central Alps, originated from their higher summits and valleys, and were carried down at different successive periods in a regular manner, forming uninterrupted walls and ridges, which can be traced from their starting point to their extreme peripheric distribution.

I have myself shown that there are such centres of distribution in Scotland and England and Ireland. And these facts have been since traced in detail in various parts of the British Islands by Dr. Buckland, Sir Ch. Lyell, Mr. Darwin, Mr. McLachlan and Professor James D. Forbes, pointing clearly to the main mountain groups as to so many distinct centres of dispersion of these loose materials.

Similar phenomena have been shown in the Pyrenees, in the Black Forest, and in the Vosges, showing beyond question, that whatever might have been the cause of the dispersion of erratic boulders, there are several separate centres of their distribution to be distinguished in Europe. But there is another question connected with this local distribution of boulders which requires particular investigation, the confusion of which with the former has no doubt greatly contributed to retard our real progress in understanding the general question of the distribution of erratics.

It is well known that Northern Europe is strewed with boulders, extending over European Russia, Poland, Northern Germany, Holland and Belgium. The origin of these boulders is far north in Norway, Sweden, Lapland and Liefland, but they are now diffused over the extensive plains west of the Ural Mountains. Their arrangement, however, is such that they cannot be referred to one single point of origin, but only in a general way to the northern tracts of land which rise above the level of the sea in the Arctic regions. Whether these boulders were transported by the same agency as those arising from distinct centres, on the main continent of Europe, has been the chief point of discussion. For my own part, I have indeed no doubt that the extreme consequences to which we are naturally carried by admitting that ice was also the agent in transporting the northern erratics to their present positions, has been the chief objection to the view that the Alpine boulders have been distributed by glaciers.

It seemed easier to account for the distribution of the northern erratics by currents, and this view appearing satisfactory to those who supported it, they at once went further, and opposed the glacial theory even in those districts where the glaciers seemed to give a more natural and more satisfactory explanation of the phenomena. To embrace the whole question it should be ascertained,

First, Whether the northern erratics were transported at the same time as the local Alpine boulders, and if not, which of the

phenomena preceded the other; and again, if the same cause acted in both cases, or if one of the causes can be applied to one series of these phenomena, and the other cause to the other series. An investigation of the erratic phenomena in North America seems to me likely to settle this question, as the northern erratics occur here in an undisturbed continuation over tracts of land far more extensive than those in which they have been observed in Europe. For my own part, I have already traced them from the eastern shores of Nova Scotia through New England and the North Western States of North America and the Canadas as far as the western extremity of Lake Superior, a region embracing about thirty degrees of longitude. Here, as in Northern Europe, the boulders evidently originated farther north than their present location, and have been moved universally in a main direction from north to south.

From data which are, however, rather incomplete, it can be further admitted that similar phenomena occur further west across the whole continent, everywhere presenting the same relations. That is to say, everywhere pointing to the north as to the region of the boulders, which generally disappear about latitude 38°.

Without entering at present into a full discussion of any theoretical views of the subject, it is plain that any theory, to be satisfactory, should embrace both the extensive northern phenomena in Europe and North America, and settle the relation of these phenomena to the well-authenticated local phenomena of Central Europe.

Whether America itself has its special local circumscribed centres of distribution or not, remains to be seen. It seems, however, from a few facts observed in the White Mountains, that this chain, as well as the mountains of northeastern New York, has not been exclusively—and for the whole duration of the transportation of these materials—under the influence of the cause which has distributed the erratics through such wide space over the continent of North America. But whether this be the case or not, (and I trust local investigations will soon settle the question,) I maintain that the cause which has transported these boulders in the American continent must have acted simultaneously over the whole ground which these boulders cover, as they present throughout the continent an uninterrupted sheet of loose materials, of the same general nature, connected in the same general manner, and evidently dispersed at the same time.

Moreover, there is no ground, at present, to doubt the simultaneous dispersion of the erratics over Northern Europe and Northern America. So that the cause which transported them, whatever it may be, must have acted simultaneously over the whole tract of land west of the Ural Mountains, and east of the Rocky Mountains, without assuming any thing respecting North-

ern Asia, which has not yet been studied in this respect; that is to say, at the same time, over a space embracing two hundred degrees of longitude.

Again, the action of this cause must have been such, and I insist strongly upon this as a fundamental point, the momentum with which it acted must have been such, that after being set in motion in the north, with a power sufficient to carry the large boulders which are found everywhere over this vast extent of land, it vanished or was stopped after reaching the thirty-fifth degree of northern latitude.

Now it is my deliberate opinion that natural philosophy and mathematics may settle the question, whether a body of water of sufficient extent to produce such phenomena can be set in motion with sufficient velocity to move all these boulders, and nevertheless stop before having swept over the whole surface of the globe. Hydrographers are familiar with the action of currents, with their speed, and the power with which they can act. They know also how they are distributed over our globe. And, if we institute a comparison, it will be seen that there is nowhere a current running from the poles towards the lower latitudes, either in the northern or southern hemisphere, covering a space equal to one-tenth of the currents which should have existed to carry the erratics into their present position. The widest current is west of the Pacific, which runs parallel to the equator, across the whole extent of that sea from east to west, and the greatest width of which is scarcely fifty degrees. This current, as a matter of course, establishes a regular rotation between the waters flowing from the polar regions towards lower latitudes.

The Gulf Stream on the contrary runs from west to east, and dies out towards Europe and Africa, and is compensated by the currents from Baffin's Bay and Spitzbergen emptying into the Atlantic, while the current of the Pacific, moving towards Asia and carrying floods of water in that direction, is maintained chiefly by antarctic currents, and those which follow the western shore of America from Behring's Straits. Wherever they are limited by continents, we see that the waters of these currents, even when they extend over hundreds of degrees of latitude, as the Gulf Stream does in its whole course, are deflected where they cannot follow a straight course.

Now without appealing with more detail to the mechanical conditions involved in this inquiry, I ask every unprejudiced mind acquainted with the distribution of the northern boulders, whether there was any geographical limitation to the supposed northern current to cause it to leave the northern erratics of Europe in such regular order, with a constant bearing from north to south, and to form, on its southern termination, a wide, regular zone from Asia to the western shores of Europe, north of the fiftieth

degree of latitude, before it had reached the great barrier of the Alps? I ask whether there was such a barrier in the unlimited plains which stretch from the Arctic seas uninterrupted over the whole northern continent of America as far down as the Gulf of Mexico?

I ask, again, why the erratics are circumscribed within the northern limits of the temperate zone, if their transportation is owing to the action of water currents? Does not, on the contrary, this most surprising limit within the arctic and northern temperate zones, and in the same manner within the antarctic and southern temperate zones, distinctly show that the cause of transportation is connected with the temperature or climate of the countries over which the phenomena were produced. If it were otherwise, why are there no systems of erratics with an east and west bearing, or in the main direction of the most extensive currents flowing at present over the surface of our globe?

It is a matter of fact, of undeniable fact, for which the theory has to account, that in the two hemispheres the erratics have direct reference to the polar regions, and are circumscribed within the arctics and the colder part of the temperate zone. This fact is as plain as the other fact, that the local distribution of boulders has reference to high mountain ranges, to groups of land raised above the level of the sea into heights, the temperature of which is lower than the surrounding plains. And what is still more astonishing, the extent of the local boulders, from their centre of distribution reaches levels, the mean annual temperature of which corresponds in a surprising manner with the mean annual temperature of the southern limit of the northern erratics.

We have, therefore, in this agreement a strong evidence in favor of the view that both the phenomena of local mountain erratics in Europe and of northern erratics in Europe and America have probably been produced by the same cause.

The chief difficulty is in conceiving the possibility of the formation of a sheet of ice sufficiently large to carry the northern erratics into their present limits of distribution; but this difficulty is greatly removed when we can trace, as in the Alps, the progress of the boulders under the same aspect from the glaciers now existing, down into regions where they no longer exist, but where the boulders and other phenomena attending their transportation show distinctly that they once existed.

Without extending further this argumentation, I would call the attention of the unprejudiced observer to the fact, that those who advocate currents as the cause of the transportation of erratics, have, up to this day, failed to show, in a single instance, that currents can produce all the different phenomena connected with the transportation of the boulders which are observed everywhere in the Alps, and which are still daily produced there by the small

glaciers yet in existence. Never do we find that water leaves the boulders which it carries along in regular walls of mixed materials; nor do currents any where produce upon the hard rocks *in situ* the peculiar grooves and scratches which we see everywhere under the glacier and within the limits of their ordinary oscillations.

Water may polish the rocks, but it nowhere leaves straight scratches upon their surface; it may furrow them, but these furrows are sinuous, acting more powerfully upon the soft parts of the rocks or fissures already existing; whilst glaciers smooth and level uniformly, the hardest parts equally with the softest, and, like a hard file, rub to uniform continuous surfaces the rocks upon which they move.

But now let us return to our special subject, the erratics of North America.

The phenomena of drift are more complicated about Lake Superior than I have seen them any where else; for, besides the general phenomena which occur everywhere, there are some peculiarities noticed which are to be ascribed to the lake as such, and which we do not find in places where no large sheet of water has been brought into contact with the erratic phenomena. In the first place, we notice about Lake Superior an extensive tract of polished, grooved and scratched rocks, which present here the same uniform character which they have everywhere. As there is so little disposition, among so many otherwise intelligent geologists, to perceive the facts as they are, whenever they bear upon the question of drift, I cannot but repeat, what I have already mentioned more than once, but what I have observed again here over a tract of some fifteen hundred miles, that the rocks are everywhere smoothed, rounded, grooved and furrowed in a uniform direction. The heterogeneous materials of which the rocks consist are cut to one continuous uniform level, showing plainly that no difference in the polish and abrasion can be attributed to the greater or less resistance on the part of the rocks, but that a continuous rasp cut down every thing, adapting itself, however, to the general undulations of the country, but nevertheless showing, in this close adaptation, a most remarkable continuity in its action.

That the power which produced these phenomena moved in the main from north to south, is distinctly shown by the form of the hills, which present abrupt slopes, rough and sharp corners towards the south, while they are all smoothed off towards the north.

Indeed, here, as in Norway and Sweden, there is on all the hills a lee-side and a strike-side. As has been observed in Norway and Sweden, the polishing is very perfect in many places, sometimes strictly as brilliant as a polished metallic surface, and

everywhere these surfaces are more or less scratched and furrowed, and both scratches and furrows are rectilinear, crossing each other under various angles: however, never varying many points of the compass on the same spot, but in general showing that where there are deviations from the most prominent direction, they are influenced by the undulations of the soil. It has been said, that the main direction of these striæ was from northwest to southeast, but I have found it as often strictly from north to south, or even from northeast to southwest; and if we are to express a general result, we should say that the direction, assigned by all our observations to the various scratches, tends to show that they have been formed under the influence of a movement from north to south, varying more or less to the east and west, according to local influences in the undulations of the soil. It is, indeed, a very important fact, that scratches which seem to have been produced at no great intervals from each other, are not absolutely parallel, but may diverge for ten, fifteen, or more degrees.

There is one feature in these phenomena, however, in which we never observe any variation. The continuity of these lines is absolutely the same everywhere. They are rectilinear and continuous, and cannot be better compared than with the effects of stones or other hard materials dragged in the same direction upon flat or rolling surfaces; they form simple scratches extending for yards in straight lines, or breaking off for a short space to continue again in a straight line in the same direction, just as if interrupted by a jerk. There are also deeper scratches of the same kind, presenting the same phenomena, only, perhaps, traceable for a greater distance than the finer ones. These scratches, instead of appearing like the tracing of diamonds upon glass, as the former do, would rather assume the appearance of a deeper groove, made by the point of a graver, or perhaps still more closely resemble the scratches which a cart-wheel would produce upon polished marble, if the wheel were chained, and coarse sand spread over the floor, the wheel continuing to move onward but without revolving. The appearance of the surface, crushed by the moving mass, is especially distinct in limestone rocks, where grooves are seldom nicely cut, but present the appearance of a violent pressure combined with the grooving power, thus giving to the groove a character which is quite peculiar, and which at once strikes an observer who has been familiar with its characteristic aspect. Now, I do not know upon what the assertions of some geologists rest, that gravel moved by water under strong heavy currents will produce similar effects. Wherever I have gone since studying these phenomena, I have looked for such cases, and have never yet found modern gravel currents produce any thing more than a smooth surface with undulating furrows

following the cracks in the rocks, or hollowing their softer parts; but continuous straight lines, especially such crushed lines and straight furrows, I have never seen.

When we know how extensive the action of water carrying mud and gravel is on every shore and in every water current,—when we can trace this action almost everywhere, and no where find it similar to the phenomena just described, I cannot imagine upon what ground these phenomena are still attributed to the agency of currents. This is the less rational as we have at present, in all high mountain chains of the temperate zone, other agents, the glaciers, producing these very same phenomena, with precisely the same characters, to which, therefore, a sound philosophy should ascribe, at least conditionally, the northern and Alpine polished surfaces, and scratched and grooved rocks, or at least acknowledge that the effect produced by the action of glaciers more nearly resembles these erratic phenomena than does that which results from the action of currents. But such is the prejudice of many geologists, that those keen faculties of distinction and generalization, that power of superior perception and discrimination which have led them to make such brilliant discoveries in geology in general, seem to abandon them at once as soon as they look at the erratics. The objection made by a venerable geologist, that the cold required to form and preserve such glaciers, for any length of time, would freeze him to death, is as childish as the apprehension that the heavy ocean currents, the action of which he sees everywhere, might have swept him away.*

Now that these phenomena have been observed extensively, we may derive also some instruction from the limits of their geographical extent. Let us see, therefore, where these polished, scratched and furrowed rocks have been observed.

In the first place they occur everywhere in the north within certain limits of the arctics, and through the colder parts of the temperate zone. They occur also in the southern hemisphere, within parallel limits, but in the plains of the tropics, and even in the warmer parts of the temperate zone we find no trace of these phenomena, and nevertheless the action of currents could not be less there, and could not at any time have been less than in the colder climates. It is true, similar phenomena occur in Central Europe and have been noticed in Central Asia, and even in the Andes of South America, but these always in higher regions, at definite levels above the surface of the sea, everywhere indicating a connection between their extent and the colder temperature of the places over which they are traced.

---

* Berlin Academy, 1846.

More recently, a step towards the views I entertain of this subject, has been made by those geologists who would ascribe them to the agency of icebergs. Here, as in my glacial theory, ice is made the agent; floating ice is supposed to have ground and polished the surfaces of rocks, while I consider them to have been acted upon by terrestrial glaciers. To settle this difference we have a test which is as irresistible as the other arguments already introduced.

Let us investigate the mode of action, the mode of transportation of icebergs, and let us examine whether this cause is adequate to produce phenomena for which it is made to account. As mentioned above, the polished surfaces are continuous over hills, and in depressions of the soil, and the scratches which run over such undulating surfaces are nevertheless continuous in straight lines. If we imagine icebergs moving upon shoals, no doubt they would scratch and polish the rocks in a way similar to moving glaciers. But upon such localities they would sooner or later be stranded, and if they remained loose enough to move, they would, in their gyratory movements, produce curved lines, and mark the spots where they had been stranded with particular indications of their prolonged action. But nowhere upon arctic ground do we find such indications. Everywhere the polished and scratched surfaces are continuous in straight juxtaposition.

Phenomena analogous to those produced by icebergs would only be seen along the sea-shores; and if the theory of drifted icebergs were correct, we should have, all over those continents where erratic phenomena occur, indications of retreating shores as far as the erratic phenomena are found. But there is no such thing to be observed over the whole extent of the North American continent, nor over Northern Europe and Asia, as far as the northern erratics extend. From the arctics to the southernmost limit of the erratic distribution, we find nowhere the indications of the action of the sea as directly connected with the production of the erratic phenomena. And wherever the marine deposits rest upon the polished surfaces of ground and scratched rocks, they can be shown to be deposits formed since the grooving and polishing of the rocks, in consequence of the subsidence of those tracts of land upon which such deposits occur.

Again, if we take for a moment into consideration the immense extent of land covered by erratic phenomena, and view them as produced by drifted icebergs, we must acknowledge that the icebergs of the *present period* at least, are insufficient to account for them, as they are limited to a narrower zone. And to bring icebergs in any way within the extent which would answer for the extent of the distribution of erratics, we must assume that the northern ice fields, from which these icebergs could be detached and float southwards, were much larger at the time they produced

such extensive phenomena than they are now. That is to say, we must assume an ice period; and if we look into the circumstances we shall find that this ice period, to answer to the phenomena, should be nothing less than an extensive cap of ice upon both poles. This is the very theory which I advocate; and unless the advocates of an iceberg theory go to that length in their premises, I venture to say, without fear of contradiction, that they will find the source of their icebergs fall short of the requisite conditions which they must assume, upon due consideration, to account for the whole phenomena as they have really been observed.

But without discussing any farther the theoretical views of the question, let me describe more minutely the facts as observed on the northern shores of Lake Superior. The polished surfaces, as such, are even, undulating, and terminate always above the rough lee-side turned to the south, unless upon gentle declivities, where the polished surfaces extend in unbroken continuity upon the southern surfaces of the hills, as well as upon their northern slopes. On their eastern and western flanks, shallow valleys running east and west are as uniformly polished as those which run north and south; and this fact is more and more evident, wherever scratches and furrows are also well preserved and distinctly seen, and by their bearings we can ascertain most minutely, the direction of the onward movement which produced the whole phenomena. Nothing is more striking in this respect than the valleys or depressions of the soil running east and west, where we see the scratches crossing such undulations at right angles, descending along the southern gentle slope of a hill, traversing the flat bottom below, and rising again up the next hill south, in unbroken continuity. Examples of the kind can be seen everywhere in those narrow inlets, with shallow waters intersecting the innumerable highlands along the northern shores of Lake Superior, where the scratches and furrows can be traced under water from one shore to the other, and where they at times ascend steep hills, which they cross at right angles along their northern slope, even when the southern slope, not steeper in itself, faces the south with rough escarpments.

The scratches and furrows, though generally running north and south, and deviating slightly to the east and west, present in various places remarkable anomalies, even in their general course along the eastern shore of the lake. Between Michipicotin and Sault St. Marie we more frequently see a deflection to the west than a due north and south course, which is rather normal along the northern shore proper, between Michipicotin and other islands, and from the Pic to Fort William; the deep depression of the lake being no doubt the cause of such a deviation, as large masses of ice could accumulate in this extensive hollow cavity

before spreading again more uniformly beyond its limits. To the oscillations of the whole mass in its southerly movement, according to the inequalities of the surfaces, we must ascribe the crossing of the straight lines at acute angles, as we observe also at the present day under the glaciers, as they swell and subside, and hence meet with higher and lower obstacles in their irregular course between the Alpine valleys.

In deep, narrow chasms, however, we find now and then greater deviations from the normal direction of the striæ, where considerable masses of ice could accumulate, and move between steep walls under a lateral pressure of the masses moving onwards from the north. Such a chasm is seen between Spar Island and the main land opposite Prince's Location, south of Fort William, where the furrows and scratches run nearly east and west. But here also, there is no tumultuous disturbance in the continuation of the phenomena, such as would occur if icebergs were floated and stranded against the southern barrier. The same continuity of even, polished surfaces, with their scratches and furrows, prevails here as elsewhere. The angles which these scratches form with each other are very acute, generally not exceeding 10°; but at times they diverge more, forming angles of 15°, 20° and 25°. In a few instances, I have even found localities where they crossed each other at angles of no less than 30°; but these are rare exceptions. It may sometimes be noticed that the lines running in one direction form a system by themselves, varying very little from strict parallelism with each other, but crossing another system, more or less strongly marked, of other lines equally parallel with each other. At other times, a system of lines, strongly marked and diverging very slightly, seem to pass over another system, in which the lines form various angles with each other. Again, there are places,—and this is the most common case,—where the lines diverge slightly, following, however, generally one main direction, which is crossed by fewer lines, forming more open angles. These differences, no doubt, indicate various oscillations in the movement of the mass which produced the lines, and show probably its successive action, with more or less intensity, upon the same point at successive periods, in accordance with the direction of the moving force at each interval. The same variations within precisely the same limits may be noticed in our day on the margin of the glaciers produced by the increase or diminution of the bulk of their mass, and the changes in the rate of their movement.

The loose materials which produced, in their onward movement under the pressure force, such polishing and grooving, consisted of various sized boulders, pebbles and gravels, down to the most minute sand and loamy powder. Accumulations of such materials are found everywhere upon these smooth surfaces, and

in their arrangement they present everywhere the most striking contrast when compared with deposits accumulated under the agency of water. Indeed, we nowhere find this glacial drift regularly stratified, being everywhere irregular accumulations of loose materials, scattered at random without selection, the coarsest and most minute particles being piled irregularly in larger or smaller heaps, the greatest boulders standing sometimes uppermost, or in the centre, or in any position among smaller pebbles and impalpable powder.

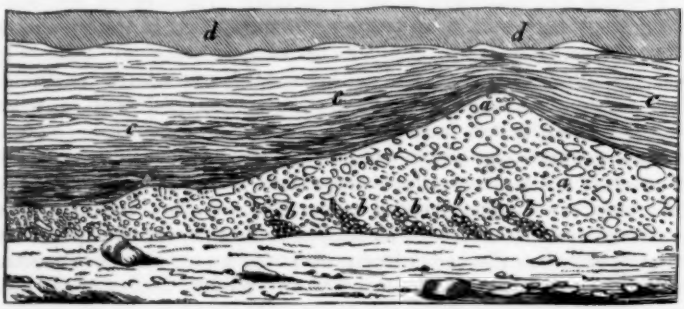
And these materials themselves are scratched, polished and furrowed, and the scratches and furrows are rectilinear as upon the rocks *in situ* underneath, not bruised simply, as the loose materials carried onward by currents or driven against the shores by the tides, but regularly scratched, as fragments of hard materials would be if they had been fastened during their friction against each other, just as we observe them upon the lower surface of glaciers where all the loose materials set in ice, as stones in their setting, are pressed and rubbed against underlying rocks. But the setting here being simply ice, these loose materials, fast at one time and movable another, and fixed and loosened again, have rubbed against the rock below in all possible positions; and hence not only their rounded form, but also their rectilinear grooving. How such grooves could be produced under the action of currents, I leave to the advocates of such a theory to show, as soon as they shall be prepared for it.

I should not omit here to mention a fact which, in my opinion, has a great theoretical importance, namely, that in the northern erratics, even the largest boulders, as far as I know, are rounded, and scratched and polished, at least, all those which are found beyond the immediate vicinity of the higher mountain ranges; showing that the accumulations of ice which moved the northern erratics covered the whole country; and this view is sustained by another set of facts equally important, namely, that the highest ridges, the highest rugged mountains, at least, in this continent and north of the Alps in Europe, are as completely polished and smoothed as the lower lands, and only a very few peaks seem to have risen above the sheet of ice; whilst, in the Alps, the summits of the mountains stand generally above these accumulations of ice, and have supplied the surface of the glaciers with large numbers of angular boulders, which have been carried upon the back of glaciers to the lower valleys and adjacent plains without losing their angular forms.

With respect to the irregular accumulation of drift-materials in the north, I may add that there is not only no indication of stratification among them, such unquestionably as water would have left, but that the very nature of these materials shows plainly that they are of terrestrial origin; for the mud which sticks be-

tween them adheres to all the little roughnesses of the pebbles, fills them out, and has the peculiar adhesive character of the mud ground under the glaciers, and differing entirely in that respect from the gravels and pebbles and sands washed by water currents, which leave each pebble clean, and never form adhering masses, unless penetrated by an infiltration of limestone.

Another important fact respecting this glacial drift consists in the universal absence of marine as well as freshwater fossils in its interior, a fact which strengthens the view that they have been accumulated by the agency of strictly terrestrial glaciers; such is, at least, the case everywhere far from the sea-shore. But we may conclude that these ancient glaciers reached, upon various points, the sea-shore at the time of their greatest extension, just as they do at present in Spitzbergen and other arctic shores; and that therefore, in such proximity, phenomena of contact should be observed, indicating the onward movement of glacial material into the ocean, such as the accumulation within these materials of marine fossil remains, and also the influence of the tidal movements upon them. And now such is really the case. Nearer the sea-shores we observe distinctly, in some accumulations of the drift, faint indications of the action of the tide reaching the lower surface of glaciers, and the remodeling, to some extent, of the materials which there poured into the sea. A beautiful example of the kind may be observed near Cambridge, along Charles River, not far from Mount Auburn, where the unstratified glacial



drift (*a*) presents in its upper masses strictly the characters of true terrestrial glacial accumulation, but shows underneath faint indications (*b*) of the action of tides. Above, regular tidal strata (*c*) are observed, formed probably after the masses below had subsided. The surface of this accumulation is covered with soil (*d*).

The period at which these phenomena took place cannot be fully determined, nor is it easy to ascertain whether all glacial drift is contemporaneous. It would seem, however, as if the extensive accumulation of drift all around the northern pole in Eu-

rope, Asia and America was of the same age as the erratics of the Alps. The climatic circumstances capable of accumulating such large masses of ice around the north pole, having, no doubt, extended their influence over the temperate zone, and probably produced, in high mountain chains, as the Alps, the Pyrenees, the Black Forest, and the Vosges, such accumulations of snow and ice, as may have produced the erratic phenomena of those districts. But extensive changes must have taken place in the appearance of the continents over which we trace erratic phenomena, since we observe in the Old World, as well as in North America, extensive stratified deposits containing fossils which rest upon the erratics; and as we have all possible good reasons and satisfactory evidence for admitting that the erratics were transported by the agency of terrestrial glaciers, and that therefore the tracts of land over which they occur, stood at that time above the level of the sea, we are led to the conclusion that these continents have subsided since that period below the level of the sea, and that over their inundated portions animal life has spread, remains of organized beings have been accumulated, which are now found in a fossil state in the deposits formed under those sheets of water.

Such deposits occur at various levels in different parts of North America. They have been noticed about Montreal, on the shores of Lake Champlain, in Maine and also in Sweden and Russia; and, what is most important, they are not everywhere at the same absolute level above the surface of the ocean, showing that both the subsidence, and the subsequent upheaval which has again brought them above the level of the sea, have been unequal; and that we should therefore be very cautious in our inferences respecting both the continental circumstances under which the ancient glaciers were formed, and also the extent of the sea afterward, as compared with its present limits.

The contrast between the unstratified drift and the subsequently stratified deposits is so great, that they rest everywhere unconformably upon each other, showing distinctly the difference of the agency under which they were accumulated. This unconformable superposition of marine drift upon glacial drift is also beautifully shown at the above mentioned locality near Cambridge. (See Diagram.) In this case the action of tides in the accumulation of the stratified materials is plainly seen.

The various heights at which these stratified deposits occur, above the level of the sea, show plainly, that since their accumulation, the main land has been lifted above the ocean at different rates in different parts of the country; and it would be a most important investigation to have their absolute level, in order more fully to ascertain the last changes which our continents have undergone.

From the above mentioned facts, it must be at once obvious that the various kinds of loose materials, all over the northern

hemisphere, have been accumulated, not only under different circumstances, but during long-continued subsequent distinct periods, and that great changes have taken place since their deposition, before the present state of things was fully established.

To the first period,—the ice period, as I have called it,—belong all the phenomena connected with the transportation of erratic boulders, the polishing, scratching and furrowing of the rocks and the accumulation of unstratified, scratched, and loamy drift. During that period, the main land seems to have been, to some extent at least, higher above the level of the sea than now; as we observe, on the shores of Great Britain, Norway and Sweden, as well as the eastern shores of North America, the polished surfaces dipping under the level of the ocean, which encroaches everywhere upon the erratics proper, effaces the polished surfaces and remodels the glacial drift. During these periods, large terrestrial animals lived upon both continents, the fossil remains of which are found in the drift of Siberia, as well as of this continent. A fossil elephant recently discovered in Vermont* adds to the resemblance, already pointed out, between the northern drift of Europe and that of North America; for fossils of that genus are now known to occur upon the northernmost point of the western extremity of North America, in New England, in Northern Europe, as well as all over Siberia.

To the second period we would refer the stratified deposits resting upon drift, which indicate that during their deposition the northern continent had again extensively subsided under the surface of the ocean.

During this period, animals, identical with those which occur in the northern seas, spread widely over parts of the globe which are now again above the level of the ocean. But, as this last elevation seems to have been gradual, and is even still going on in our day, there is no possibility of tracing more precisely, at least for the present, the limit between that epoch and the present state of things. Their continuity seems almost demonstrated by the identity of fossil shells found in these stratified deposits, with those now living along the present shores of the same continent, and by the fact that changes in the relative level between sea and main land are still going on in our day.

Indications of such relative changes between the level of the waters and the land are also observed about Lake Superior. And here they assume a very peculiar character, as the level of the lake itself, in its relation to its shores, is extensively changed.

All around Lake Superior we observe terraces at different levels; and these terraces vary in height, from a few feet above the present level of the lake, to several hundred feet above its surface,

* See this Journal, vol. ix, p. 256.

presenting everywhere undoubted evidence, that they were formed by the waters of the lake itself.

As everywhere the lake shores are strewed with sand and pebbles stranded within certain limits by the waves, the lowest accumulations of loose materials remain within the action of heavy storms, and within such limit they are entirely deprived of vegetation.

Next, another set of beaches is observed, consisting generally of coarser materials, forming shelves above the reach of even the severest storms, as shown by the scanty cryptogamus vegetation, and a few small herbaceous plants which have grown upon them.

Next, other beaches, retreating more and more from the shores, are observed, upon which an older vegetation is traced, consisting of shrubs, small trees, and a larger number of different plants, among which extensive carpets of wonderful lichens sometimes spread over large surfaces of greater extent. And the gentle slope of some of the terraces shows that the lake must have stood at this level for a longer time, as higher banks rise precipitously above them, consisting also of loose materials, which must have been worn out and washed away, for a considerable time, by the action of the waves from the lake. In such a manner, terrace above terrace may be observed, in retreating sheltered bays or along protected shores, over extensive tracts; sometimes two or three in close proximity, perhaps within twenty to fifty feet of each other; and again, extensive flat shores, spreading above to another abrupt bank, making the former shore, above which other and other terraces are seen; six, ten, even fifteen such terraces may be distinguished on one spot, forming, as it were, the steps of a gigantic amphitheatre. The most remarkable of all the amphitheatres has been sketched by Mr. Cabot, and forms the frontispiece to this volume. Its height has been determined by Mr. Logan, in his Geographical Report of Canada, page 10, where it is minutely described. I therefore refer to this account for further details. I would only mention here, that the first shelf, within the reach of the lake, consists of minute sand, and forms a narrow strip of sterile ground along the water-edge; next, we have a slope of about 10°, followed by a flat terrace, extending for nearly fifty paces to a second very steep slope, about 26° and 30° inclination; then a sloping terrace with an inclination of near 16°, stretching for eighty to a hundred paces, above which rises another steep slope of 20°, beyond which an extensive flat, slightly sloping, extends for several hundred paces, crowned by some irregular ridges at its summit, and along the rocky ledges which form the bay at the bottom of which this high gravel bank rises.

In connection with these lake terraces, we must consider also the river terraces which present similar phenomena along their banks all around the lake, with the difference that they slope

gradually along the water courses, otherwise resembling in their composition the lake terraces, which are altogether composed of remodeled glacial drift, which, from the influence of the water and their having been rolled on the shores, have lost, more or less, their scratches and polished appearance, and have assumed the dead smoothness of water pebbles. Such terraces occur frequently between the islands, or cover low necks connecting promontories with the main land, thus showing, on a small scale, how by the accumulation of loose materials, isolated islands may be combined to form larger ones, and how, in the course of time, by the same process, islands may be connected with the main land.

The lake shores present another series of interesting phenomena, especially near the mouth of larger rivers emptying into the lake over flats, where parallel walls of loose materials, driven by the action of the lake against the mouth of the river, have successively stopped its course and caused it to wind its way between the repeated accumulations of such obstacles.

The lower course of Michipicotin River is for several miles dammed up in that way by concentric walls, across which the river has cut its bed, and winding between them, has repeatedly changed its direction, breaking through the successive walls in different places. The largest and lowest of these walls, a kind of river terrace near the margin of the lake, shuts at present the factory from the immediate lake shore, and the river, which has cut its way between the rocks to the right and the walls, has left a bold bank in this dam on its left shore.

An important question now arises, after considering these facts, how these successive changes in the relative level of the lake and its shores have been introduced. Has the water been gradually subsiding, or has the shore been repeatedly lifted up? Merely from the general inferences of the more extensive phenomena described above, respecting the relative changes between land and sea, I should be inclined to admit that the land has risen, rather than to suppose that the waters have gradually flowed out.

But there are about the lake itself sufficient proofs, which leave in my mind not the slightest doubt that it is the land which has changed its level, and not the lake which has subsided.

In the first place, to suppose that the lake had once stood as high as the highest terraces, it would be necessary to admit that its banks were, all round its shores, sufficiently high to keep the water at that highest level, or, at least, that there were, at the lower outlets, bars to that height, which have been gradually removed since. But neither is the main land sufficiently high, at the western extremity and along the southern shores, to admit of such a supposition, nor is there about the outlet of the lake, between Gros Cap and Cap Iroquois, an indication of a barrier which has been gradually removed. There, as everywhere along

the lake shores, the loose movable materials consist of the same drift, the accumulation of which, at various levels, we are aiming to account for. If, therefore, we consider this same drift as the barrier under whose protection the lake modeled other parts of its mass, we should be compelled to admit another cause to remove the barrier, a supposition for which there is not the slightest indication in the geological structure of the country. But if, on the contrary, we suppose the lake to have removed the barrier, there is no cause left for its accumulation, and the changes in the comparative level of the main land and the terraces remain equally unaccounted for.

Indeed, the terraces are so unequal in their absolute level when compared to each other, that a gradual subsidence of the lake removing a barrier of loose materials at its outlet could never explain their irregularity. But if we suppose that the innumerable dykes which cross, in all directions, the rocks which form the shores of the lake, have at various intervals lifted up these shores, we have at the same time a cause for the change of the relative level between the terraces and the lake, and also for the change of its absolute level, as it removed larger and larger portions of materials accumulated at its eastern extremity.

That these dikes have produced such changes will not be doubted by any one who may study the phenomena described in the following chapter respecting the origin of the present outlines of the lakes, as produced by the intersection of all the dikes traversing the metamorphic and plutonic rocks of the northern shores.

We should therefore conclude that, as there has been a general gradual change between the relative level of the main land and sea, so there has also been a gradual local change in the relative level of the lake and its shores; and hence the local phenomena would only corroborate the induction derived from more general geological facts.

Art. XIV.—*Crystallized Gold from California;* by Francis Alger, Boston.*

I have lately had an opportunity of examining some parcels of California gold, which have afforded specimens worthy of especial notice. Those which I purpose to describe in this paper, I obtained from the collections brought home by Mr. George E. Tyler, of this city, and Mr. H. B. Platt, of New York. They consist of well characterized octahedral crystals, simple and modified, the surfaces of which have been but slightly disfigured by

* Read, in part, before the Boston Society of Natural History, April, 1850.

attrition, or the effects of transported action usually observed in other specimens. I cannot say that I have ever before seen what was unquestionably a genuine crystal from this new land of gold; an irregular crystalline plane could only occasionally be traced out in former specimens; but here we have examples of crystallization, as perfect among the small ones especially, as are to be seen in magnetic iron ore or in spinelle. The most striking examples on a large scale, are three octahedrons of the dimensions of the accompanying figures. They are isolated crystals, and the smallest one,

which is the most perfect, is so entirely free from any adhering portion of the matrix to which it must have been attached, as to lead me to believe that this matrix was a much softer material than the quartz in connection with which the gold is usually found. Although its exact locality is not known, it is probable, as indicated by its slightly worn appearance, that it has been but recently dislodged from its original resting place. This crystal presents four pretty regular faces, and has three of its solid angles perfectly formed to a point. It exhibits no modifications; but two of its faces are depressed—one of them by a very deep cavity which extends not quite to the edges of the plane, but so near to them as to leave a narrow ridge, or border, all around the cavity and parallel with the edges, thus giving the same triangular outline to each. It appears as if the crystal had been in a liquid state, and that soon after the outside had congealed, the inner portion, or a part of it, had run out, leaving the surrounding consolidated edge just referred to. I have seen something similar to this formed among artificial crystals, as for instance, metallic lead (which takes the form of an octahedron) and lead ore partially desulphurized, when the metal was allowed to flow off slowly, just as the outer crust had formed over the surface of the crystals.

The large crystal presents only one half of the octahedron, its base blending with the massive gold, or only indicating the incipient planes of the lower pyramid. Three of its planes are perfectly smooth surfaces, excepting along their edges, which are prominently marked by the same projecting border or ridge already described on the smaller crystal. This border may have been produced in the same manner by the shrinking away of the

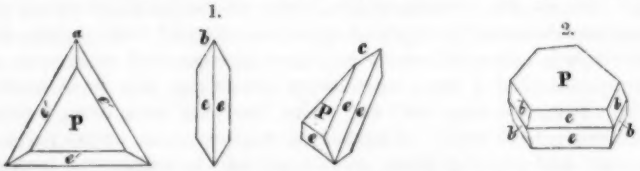
metal, or it may be the result of that kind of crystallization which is dependent on a greater intensity of molecular attraction in one direction, or axis, than another. It would seem in this case, as if the molecules arrived at the points of contact along the edges of the crystal, faster than they could be appropriated, and thus they have accumulated in these little ridges. This peculiarity is not confined to the large crystals, for it is observed even among the smallest; but it is confined to the unmodified octahedrons. In a few crystals, there is a double series of these ridges, the inner one representing, apparently, the commencement of another crystalline face within the cavity of the larger one. This is beautifully shown in the third figure on the last page, also answering to the natural size of the crystal.*

The great size of these crystals, and the fact that some of the cavities contained portions of oxyd of iron probably produced by the decomposition of pyrites, have led some to regard them as pseudomorphs of sulphuret of iron. I am not disposed to ascribe any such forced and unnatural origin to these beautiful productions. I believe them to have been formed under the ordinary circumstances of crystallization, either in an open space, or while surrounded by a matrix so soft and accommodating, as to allow them full freedom to take the form it was intended they should take. Were the crystals cubes, there might be some reason for regarding them in the light of pseudomorphs of iron pyrites, because this is the most common form of pyrites, and, moreover, all the pyrites that I have seen from California, has been in that form. But, we may well ask, who has ever seen even a cubic pseudomorph of gold? Crystals of gold are rare, cubes particularly so, and yet this form, on account of its simplicity, is made the primary form; whereas it would seem as reasonable in cases of the regular system, to select that form as the primary which is most commonly and perfectly presented by the mineral, provided there is no cleavage to guide us in the determination; and there does not appear to be any, well made out, among most of the native metals. By assuming those which most commonly occur in nature, we seem to recognize a sort of inherent disposition, a preference, as it were, which is shown by the mineral itself; and we avoid what seems to be a palpable inconsistency,

* The two large crystals above described were obtained from the very choice and beautiful collection of specimens, made with great care, and at no small expense, by Mr. Platt. This gentleman, during a most prosperous residence of two years in San Francisco, and while occupying a situation which brought him into daily and almost hourly contact with persons returning from the mines, has evinced his good taste by purchasing the most interesting specimens obtained by them. He has consequently been rewarded by the finest amateur collection hitherto brought from California. It comprises a great variety of ramified, arborescent, dendritic and other imitative forms, here and there showing crystalline faces, all of them being sometimes most fantastically joined together in the same specimen. He informs me that in obtaining this collection, he had examined gold to the amount of more than four millions of dollars.

viz., the establishing of a cube as the primary form of minerals which have never been known to occur under such form, and which even present a distinct octahedral cleavage. This is the case with two at least. If we take the simplest form, the cube should be made the primary of native iron, copper, lead, silver, and mercury; and so of some others, which occur in octahedrons and are not determined by any certain cleavage. In the case of copper, some authors have made the cube its primary.* Haüy (Traité, 1808) even expressed his doubts as to the existence of cubic gold, while he cites examples of the octahedron; and Beudant, (Min., 1832,) says they are very rare.† Mohs implies the contrary, for he says (Min. Ed. by Haidinger) they are often hollow, while the octahedrons are smooth. Cleaveland describes the crystals in general as small and imperfect, and Nicol, in his late work, in the like manner, observes, "they are small and very small." I hope we may yet say of our California gold crystals, they are large and very large, as much for the benefit of mineralogists, as a reward to the industry and hard toil of the diggers.

Crystals of rare modifications.—Among the specimens collected by Mr. Tyler, I have found several rare modifications of this metal, such as come to us in their most perfect forms from Brazil. I here give figures of two of them. One, fig. 1, (*a*, *b*, *c*,)



represents a compound form produced by the union of two opposite sections, or segments, of an emarginated octahedron; a form not unfrequently presented by octahedral spinelle. The other, fig. 2, has the apparent form of irregular six-sided tables, with truncated edges, and is a modification of the same form. They are tolerably well represented by the figures referred to, but the planes of the dodecahedron (*e*) are less conspicuously defined on the real crystals, owing to their extreme thinness, and their edges being rounded off, or otherwise disfigured. For this reason, we can distinguish but two of the primary octahedral planes on any of these crystals. Crystals somewhat resembling

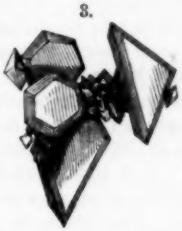
* They differ in regard to silver and iron, some adopting the cube, and others the octahedron, as the primary.

† Cronstedt, in his Mineralogy, says, "I have procured in Transylvania a specimen of cubic native gold, but I have never seen it any where else." In Levy's enumeration of the splendid Turner collection formed by Henry Heuland, eight examples are given of the regular octahedron, and only two of the cube, one of these being from the very locality Cronstedt speaks of.

fig. 2, have been brought from Brazil and Siberia; they had the same flattened form of six-sided tables, but they are the result of a different kind of modification, and are not macles. Dufrénoy and Levy,* have each given a figure of a very perfect example of the modification here referred to (*triforme* of Haüy) derived from the cube, octahedron and dodecahedron; and I was at first, inclined to regard my crystals as the same, only more deeply truncated on the solid angles *a*, as lettered by Dufrénoy. Further examination however, proved them to be the same macled combination as fig. 1, with the additional replacements indicated by the letters *b*, which have changed the triangular faces P, and the whole crystal, into a hexagonal figure as above represented. These new planes are sometimes unequally extended, and roughened by inequalities, while the primary faces P, are perfectly smooth and brilliant.†

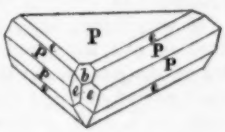
Some of the unmodified macles, as shown in different positions by fig. 1, *a*, *b*, *c*, are very distinctly formed, the edges between *e e*, uniting the two segments of the octahedron, being well defined. This is the most strikingly shown on the largest of these crystals, the lowest one of the group represented by fig. 3.‡ Owing to its position, it is only partially visible in the group as here drawn, and fig. 4 is intended to show it as it appears on the opposite side of the specimen in juxtaposition with two other crystals, one a very beautiful and smooth planed octahedron with emarginated edges. Dufrénoy has described a macle of gold quite similar to fig. 1, and it may be seen figured in the volume of elegant and copious crystallographic illustrations which accompany his treatise.§ It came from Matto-Grosso, in Brazil, and is in the collection of the School of Mines, Paris. It differs from the example here described, in exhibiting more of the planes of the octahedron and dodecahedron. Fig. 5 is a copy of his figure, but regarding the octahedron as the primary form of gold, I have, besides conforming his lettering to the notation of Phillips, made primary planes of those which he gives only as secondaries of the cube.

3.



4.

5.



It should be observed that as nearly all of these crystals show the effects of more or less abraded action, it is often difficult to

* Fig. 576, plate 144, of Dufrénoy's, and fig. 3, plate 47, of Levy's Atlas of Plates.

† In the Turner collection there is a single macle crystal answering almost exactly to fig. 2, and Levy has figured it in his Atlas, plate 47, fig. 4.

‡ This group represents the figures as magnified to about twice their natural size.

§ Atlas, plate 145, fig. 581.

distinguish planes confined within such narrow limits, and which are too small or too rough to admit of accurate measurement. We can hardly expect to see many perfect crystals from California, until the rocks themselves are systematically explored, from whence have proceeded the millions of fragments that are now scattered over the plains and valleys. We may then, from the indications already afforded, look for crystals of gigantic dimensions, and possessing all their native unaltered beauty.

Boston, May 17, 1850.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Diffusion of Liquids;* by Professor Graham, F.R.S., (Proc. Roy. Soc., Phil. Mag., Feb., 1850, vol. xxxvi, p. 139.)—The apparatus used in studying the diffusion of salts and other substances into water was very simple. It consisted of an open phial to contain the solution of the salt to be diffused, which was entirely immersed in a large jar of pure water, so that the solution in the phial communicated freely with the latter. Phials cast in a mould of the capacity of four ounces of water, or more nearly 2000 grains, were generally employed, which were ground down to a uniform height of 3·8 inches. The neck was 0·5 inch in depth, and the aperture or mouth of the phial 1·25 inch in diameter. The phial was filled up with the solution to be diffused till it reached the point of a pin dipping exactly 0·5 inch into the mouth of the bottle. This being the solution cell or bottle, and the external jar the "water-jar," the pair together form a "diffusion cell." The diffusion was stopped, generally after seven or eight days, by closing the mouth of the phial with a plate of glass, and then raising it out of the water-jar. The quantity of salt which had found its way into the water-jar—the diffusion product as it was called—was then determined by evaporating to dryness.

The characters of liquid diffusion were first examined in detail with reference to common salt.

It was found, first, that with solutions containing 1, 2, 3 and 4 per cent. of salt, the quantities which diffused out of the phials into the water of the jars, and were obtained by evaporating the latter, in a constant period of eight days, were as nearly in proportion to these numbers, as 1, 1·99, 3·01 and 4·00; and that in repetitions of the experiments, the results did not vary more than $\frac{1}{10}$th part. The proportion of salt which diffused out in such experiments amounted to about $\frac{1}{8}$th of the whole.

Secondly, that the proportion of salt diffused increases with the temperature; an elevation of 80° F. doubling the quantity of chlorid of sodium diffused in the same time.

The diffusibility of a variety of substances was next compared, a solution of 20 parts of the substance in 100 water being always used.

Some of the results are as follows, the quantities diffused being expressed in grains: chlorid of sodium 58·68, sulphate of magnesia 27·42, sulphate of water 69·32, crystallized cane-sugar 26·74, starch-sugar 26·94, gum-arabic 13·24, albumen 3·03. The low diffusibility of albumen is very remarkable, and the value of this property in retaining the serous fluids within the blood-vessels at once suggests itself. It was further observed, that common salt, sugar and urea, added to the albumen under diffusion, diffused away from the latter as readily as from their aqueous solutions. Urea itself is as highly diffusible as chlorid of sodium.

In comparing the diffusion of salts dissolved in 10 times their weight of water, it was found that isomorphous compounds generally had an equal diffusibility, chlorid of potassium corresponding with chlorid of ammonium, nitrate of potash with nitrate of ammonia, and sulphate of magnesia with sulphate of zinc. The most remarkable circumstance is that these pairs are "equi-diffusive," not for chemically equivalent quantities, but for equal weights simply. The acids differed greatly in diffusibility, nitric acid being nearly four times more diffusive than phosphoric acid; but these substances also fell into groups, nitric and hydrochloric acids appearing to be equally diffusive; so also acetic and sulphuric acids. Soluble sub-salts and the ammoniated salts of the metals present a surprisingly low diffusibility; the quantities diffused in similar circumstances of the three salts, sulphate of ammonia, sulphate of copper, and the blue ammonio-sulphate of copper being very nearly as 8, 4 and 1.

When two salts are mixed in the solution-cell, they diffuse out into the water atmosphere separately and independently of each other, according to their individual diffusibilities. This is quite analogous to what happens when mixed gases are diffused into air. An important consequence is, that in liquid diffusion we have a new method of separation or analysis for many soluble bodies, quite analogous in principle to the separation of unequally volatile substances in the process of distillation. Thus, it was shown that chlorids diffuse out from sulphates and carbonates, and salts of potash from salts of soda; and that from sea-water the salts of soda diffuse out into pure water faster than the salts of magnesia. The latter circumstance was applied to explain the discordant results which have been obtained by different chemists in the analyses of the water of the Dead Sea, taken near the surface; the different salts diffusing up into the sheet of fresh water, with which the lake is periodically covered, with unequal velocity.

It was further shown that chemical decompositions may be produced by liquid diffusion; the constituents of a double salt of so much stability as common alum being separated, and the sulphate of potash diffusing in the largest proportion. In fact the diffusive force is one of great energy, and quite as capable of breaking up compounds as the unequal volatility of their constituents. Many empirical operations in the chemical arts, it was said, have their foundation in such decompositions.

Again, one salt, such as nitrate of potash, will diffuse into a solution of another salt, such as nitrate of ammonia, as rapidly as into pure water; the salts appearing mutually diffusible, as gases are known to be.

Lastly, the diffusibilities of the salts into water, like those of the gases into air, appear to be connected by simple numerical relations.

These relations are best observed when dilute solutions of the salts are diffused from the solution-cell, such as 4, 2 or even 1 per cent. of salt. The quantities diffused in the same time from 4 per cent. solutions of the three salts, carbonate of potash, sulphate of potash, and sulphate of ammonia, were 10·25, 10·57, and 10·51 grains respectively; and a similar approach to equality was observed in the 1, 2, and $6\frac{2}{3}$ per cent. solutions of the same salts. It also held at different temperatures. The acetate of potash appeared to coincide in diffusibility with the same group, and so did the ferrocyanid of potassium. The nitrate of potash, chlorate of potash, nitrate of ammonia, chlorid of potassium and chlorid of ammonium formed another equi-diffusive group. The *times* in which an equal amount of diffusion took place in these two groups appear to be as 1 for the second to 1·4142 for the first, or as 1 to the square root of 2. Now in gases, *the squares of the times* of equal diffusion are *the densities of the gases*. The relation between the sulphate of potash and nitrate of potash groups would therefore fall, to be referred to the diffusion molecule or diffusion vapor of the first group having a density represented by 2, while that of the second group is represented by 1.

The corresponding salts of soda appeared to fall into a nitrate and sulphate group also, which have the same relation to each other as the potash salts.

The relation of the salts of potash to those of soda, in times of equal diffusibility, appeared to be as the square root of 2 to the square root of 3; which gives the relation in density of their diffusion molecules, as 2 to 3. Hydrate of potash and sulphate of magnesia were less fully examined, but the first presented sensibly double the diffusibility of sulphate of potash, and four times the diffusibility of the sulphate of magnesia. If these times are all squared, the following remarkable ratios are obtained for the densities of the diffusion molecules of these different salts, each of which is the type of a class of salts, hydrate of potash 1, nitrate of potash 2, sulphate of potash 4, sulphate of magnesia 16, with nitrate of soda 3, and sulphate of soda 6.

In conclusion, it was observed, that it is these diffusion molecules of the salts which are concerned in solubility, and not the Daltonian atoms or equivalents of chemical combination; and the application was indicated of the knowledge of the diffusibilities of different substances to a proper study of endosmose.

2. *On the Occurrence of Formic Acid in Stinging Nettles;* by Dr. Gorup-Besanez, (Journ. für Prakt. Chem., xlviii, p. 191; Chem. Gaz., Jan. 1, 1850, p. 8.—Some time ago, F. Will showed, by microchemical and microscopical experiments, that the fluid in the hairs of the so-called procession-caterpillar (*Bombyx processionaria*), which causes an inflammation of the skin, as well as the liquid in the poisonous organs of some insects, is nothing else than formic acid. It became highly probable therefore that formic acid would also occur in the vegetable kingdom already formed; and the first class of plants which was thought of was that which, by means of stinging hairs of similar organs, produces an analogous effect to the sting of certain insects.

About a pound of the collected plants *Urtica urens* and *dioica*, was cut small and pressed, and submitted to distillation with about four times the quantity of water and a few drops of concentrated sulphuric acid.

The distillate was opalescent; a few oil-drops floated on its surface; it had a very offensive odor and a scarcely perceptible acid reaction. Mixed with carbonate of soda and evaporated to dryness in the water-bath, it furnished a brownish mass, a very small portion of which was deliquescent, the greater part consisting of the excess of carbonate of soda.

This mass was now very cautiously decomposed in a glass retort by the gradual addition of dilute sulphuric acid, when a distinctly acid distillate was obtained in the well-cooled receiver, which, neutralized with ammonia, gave all the reactions characteristic of formic acid. This experiment however did not appear to me to furnish a satisfactory proof of the presence of ready-formed formic acid in the plant, as formic acid can be *produced* from the most different organic substances by concentrated sulphuric acid; and it was possible that in the present case the formic acid might have been produced by decomposition towards the end of the operation.

Five pounds of stinging nettles were therefore distilled with a corresponding quantity of water without any addition of sulphuric acid, and a product obtained perfectly similar to the one above mentioned. It was neutralized with carbonate of soda, evaporated to dryness, the residue decomposed with dilute sulphuric acid, and the acid distillate digested with carbonate of lime, in order to avoid the excess of carbonic acid and excess of alkali, which rendered the reactions very indistinct, and filtered. The yellowish solution, concentrated in the water-bath, proved to be formiate of lime. It reduced salts of silver and mercury, gave with sulphuric acid the characteristic odor of formic acid, and with sulphuric acid and alcohol the still more characteristic smell of formic ether; oxalate of ammonia showed the presence of lime.

The amount of formic acid present in stinging nettles is certainly small; but this will not appear surprising, if we suppose that this acid is contained only in the stinging hairs, an assumption which is confirmed by the microscopic observations of Will and Lucas. When, for instance, solution of silver is added to the plant under the microscope, and a gentle heat applied, reduction always first occurs at the extremity of the stinging hair.

3. *Method of Preparing Theine;* by H. Heinsius, (Scheidk. Onderzoek., part v, p. 318; Chem. Gaz., March 15, 1850, p. 119.)—Stenhouse has recommended the preparation of theine from the extract of tea according to Mohr's method. The following is still more simple:—Old spoiled tea is placed in an iron pot, which is covered with filtering-paper, and the whole then covered with a cylindrical paper cap. The temperature is now cautiously and gradually raised, when a sufficient quantity of pure theine will be found to have collected on the paper.

4. *Test of the Presence of Sugar;* (L'Institut, No. 846.)—M. Maumené has mentioned a new reagent for ascertaining the presence of sugar in certain liquids. It is the bichlorid of tin. He announces his having observed, contrary to the statement of Liebig, that the chlorid acts on sugar even in the dry state. A temperature of only 100° C., is necessary for determining the reaction; and even in the cold it is produced after some time. In either case it forms a brown matter partly

soluble in water—caramel—which is brilliant black when dried. If the solution of sugar and bichlorid of tin are left to spontaneous evaporation at the ordinary temperature, the color soon becomes brown, and gradually deepens; and at the end of a year or eighteen months, it is changed to a uniform jelly of a lustrous black color. The same result takes place more rapidly on evaporating the solution by heat.

A test cloth of some woollen fabric, such as white merino, is to be applied for three or four minutes in a solution of one pint bichlorid of tin and two pints of water, the liquid allowed to drain off and the merino dried in a water-bath. For testing urine, a drop of the urine is to be put on a strip of the stuff, and held over a red hot charcoal or a candle, the presence of sugar is detected by a black stain.

Such is the delicacy of this test that ten drops of diabetic urine in about six cubic inches of water are capable of staining the merino a brownish black. Paper, linen, etc., being darkened by the chlorid cannot be used in place of wool. Ordinary urine and its constituents are not darkened by this test.

Bichlorid of mercury, chlorid of antimony, and other chlorids may be used in place of bichlorid of tin. They act by depriving the sugar of water and forming a caramel containing more carbon than ordinary caramel. Different sugars act in the same manner, and other analogous compounds, as ligneous fibre, cotton, paper, starch.

The author also suggests that the reaction of sugar and oxymuriate of tin may produce a brown paint that will become very important in the arts.

5. *On Iodine in fresh water Plants;* by Ad. Chatin, (L'Institut, 847.)—It is known that iodine has been detected by Müller in the cress, "*Nasturtium officinale*," a fresh water plant. But it does not appear to be understood that it occurs also in other plants growing in fresh waters. M. Chatin has examined numerous species, growing apart from any saline waters or sources, and has ascertained that it is of frequent occurrence. He examined with success the cress about Paris, and on extending his researches, found it in the following species.

	Iodine reaction.
Potamogeton crispum, stagnant waters of Gentilly,	traces.
" *pectinatum*, the Seine, near St. Cloud,	strong.
Arundo phragmites, marshes near Meudon,	traces.
" " marshes of St Quentin,	strong.
Scirpus lacustris, Meudon,	traces.
" " St. Quentin,	strong.
Typha latifolia, St. Quentin,	"
Littorella lacustris, St Quentin,	"
Ranunculus aquatilis var. *heterophyllus*, pools of water of Satory,	traces.
Sagittaria sagittifolia, the Seine, near Neuilly,	strong.
Chara fœtida, turfy waters, Gentilly,	traces.
Conferva crispata, Seine, near St. Cloud,	strong.
Pontinalis antipyretica, pond near Charenton,	"
Nasturtium amphibium, Meudon,	traces.
Gratiola officinalis of commerce,	"
Menyanthes trifoliata, Meudon,	"

Olisma plantago, Meudon,	traces.
Stratiotes aloïdes, pond, Marly,	"
Acorus calamus of commerce,	"
Veronica beccabunga of commerce,	"
Phellandrium aquaticum of commerce, the fruit,	"
Inula helenium of commerce,	"
Symphytum officinale of commerce,	"
Rumex nemorosus, swamp on the Seine, near Neuilly,	"
Potentilla anserina, " " "	"
Potentilla supina, marsh, St. Quentin,	"
Polygonum hydropiper of commerce,	"

Mr. Chatin concludes :—

(1.) That those plants growing in running waters, or on the borders of large bodies of water which may be strongly agitated by the winds, contain more iodine than those of stagnant waters.

(2.) That the proportion is very small in species that are imperfectly submerged or only at intervals.

(3.) That the proportion of iodine appears to be independent of the nature of the plant or its place in the natural system.

The anti-scrofulous effects of the cress, Veronica, Phellandrium, &c., are explained by the presence of iodine.

6. *Analysis of certain gold-colored Bronze Antiquities found at Dowris, near Parsonstown, in the King's County, Ireland;* by Thos. L. Cooke, (Royal Irish Acad.; Chem. Gaz., No. 181, p. 176.)—The articles were part of a celt and a portion of a horn. The golden hue of these ancient bronzes suggested to some the idea of an admixture of zinc, an ingredient never yet observed in ancient bronzes. Such was not the fact, as may be seen from the analysis. The specific gravity of the celt was 8·767. The author details his process for separating copper, tin and lead, which it is unnecessary to repeat at present.

	The celt consisted of	The horn consisted of
Copper,	85·232	79·345
Tin,	13·112	10·873
Lead,	1·142	9·115
Sulphur and carbon,	0·150	——
Loss	0·364=100.	0·667=100.

The author notices the loss of copper in the vapor of nitrous acid, which he endeavored to avoid by passing the gas evolved in the action of the nitric acid on the alloy (contained in a small tubulated retort) through ammonia solution in small Woulf's bottles. He also notices the very fine qualities of toughness and of hardening acquired by this alloy when hammered, enabling it to cut not only flesh but even bone. It also takes a fine polish.

7. *Mannite, its atomic Weight and Compounds;* by Dr. W. Knop, (Pharm-Cent. Blatt., Nov., 1849, and Jan., 1850; Chem. Gaz., Mar. 1st, and April 15th, 1850.)—The author shows that the lead compounds of Favre are mere mixtures of basic lead salts with uncombined mannite, and therefore give no aid in determining the atomic weight. No combinations with acids seem to give a favorable result—but at last a compound of formic acid was obtained, curious for the manner of its formation. Crystallized *oxalic* acid and mannite fused together at 230°,

and then allowed to remain for several hours at about 212°, gave off large quantities of formic and carbonic acids. The nearly colorless syrup cooled to a transparent mass, soluble in alcohol of 0·83, in which mannite is nearly insoluble. The solution soon decomposes into formic acid and mannite. No true salts would be formed, but the compound was found to be one equiv. of formic acid and one of mannite estimated at $C_6\ H_7\ O_6$.

The author in his first paper points out the nitric mannite as most suitable for determining the atomic weight. In his second paper he discusses the analysis of Strecker, and agrees with him that it is sex-nitrated, its formula will then be $C_{12}\ H_8\ O_{12}+6NO_4$. The reduction by metals and by sulphuret of ammonium is so unlike that of ordinary nitric compounds, that Dr. Knop brings it as a proof, that nitric acid is contained as such, and not as hyponitric acid. It must be remembered however, that chemists do not generally consider that hyponitric acid as such, is contained in these compounds.

For the preparation of explosive mannite the process of Stenhouse is said to be the best. Mannite is to be dissolved in very cold fuming nitric acid in the proportion of half an ounce to 2 ounces of acid—cold sulphuric acid is then added, until white grains cease to deposite. The mixture to be poured into a large quantity of water—the crude product dissolved in boiling alcohol and again poured into a quantity of cold water—after some time the mannite cakes and may be filtered and washed. G. C. SCHAEFFER.

8. *On Dulcose, a Homologue of Grape Sugar;* by A. LAURENT, (Comptes Rendus, Jan., 1850.)—This is a new sugar from Madagascar, of uncertain origin. After fusion its formula is $C_{28}\ H_{28}\ O_{24}$, differing from grape sugar by $C_4\ H_4$. When dissolved, it takes up 3 equivalents of water. A crystallized compound has been obtained with 4 equiv. of water.

By the action of nitric acid on dulcose, mucic acid is formed. This sugar, which has but a slightly sweetish taste, is said to be without action on polarized light and to be incapable of alcoholic fermentation.

According to Gerhardt, the erythro-mannite obtained by Dr. Stenhouse, from certain lichen, may, on the supposition of a slight error in the analysis, be considered as a homologue of mannite, which it resembles in its properties. This view however, would make the compounds with nitric acid, sex-nitric instead of quinqui-nitric, as stated by Dr. Stenhouse. Since the discovery of Strecker that nitric mannite is in fact, sex-nitric, this supposition becomes highly probable.

The discovery of a homologue of sugar opens a new field of enquiry, while it gives additional confirmation, if any were needed, to the views of MM. Gerhardt and Laurent on this subject. It is possible that some of the known varieties of sugar, may, on more careful examination, prove additional examples of homologues. G. C. S.

Among other recent investigations in connection with the subject of sugar we may mention the following:—

9. *Sugar in the Liver.*—BEQUARD and BARRESWILL have demonstrated the presence of sugar in the liver of animals, even where saccharine or amylaceous food forms no part of their diet. It is found in no other organ. G. C. S.

10. *Sugars of Honey.*—M. SOUBEIRAN has demonstrated the presence of three sugars in honey. 1st, ordinary glucose. 2nd, a sugar with right handed rotation, and alterable by acids. 3d, a sugar with left handed rotation to an amount nearly double that of the last. This is called liquid sugar of honey; it is uncrystallizable, may be converted into transparent solid sugar which melts with great ease; it is easily acted upon and destroyed by alkalies. This sugar has been kept for years without change or crystallization. G. C. S.

11. *Sugar in the flowers of Rhododendron ponticum.*—Dr. B. SLHAMER has proved that this is pure cane sugar. The honey collected by bees from these flowers is said by Tournefort to possess narcotic properties. No such substance however could be obtained by the author, and not a trace of nitrogen could be detected. G. C. S.

12. *Sugar of milk in the Cotyledons of seeds.*—H. BRACONNOT states that he has determined the presence of sugar in the cotyledons of the acorn and other seeds, and also of the other constituents of milk. These substances being found in the egg, we have a remarkable analogy in the instrument provided for the infant animal and plant. G. C. S.

13. *Production of Sugar in the urine by wounding the brain.*—M. BERNARD has found that by wounding a certain portion of the floor of the fourth ventricle, the urine in an hour and a half or two hours, resembles that of diabetes, becoming clear and abundant with a very large quantity of sugar in solution. The blood also contains a large quantity of sugar. The portion of the fourth ventricle in which a wound produces this effect, is confined to a small space a little above the origin of the 8th pair of nerves.

The results of this curious discovery promise to throw new light upon the process of digestion. G. C. S.

II. MINERALOGY AND GEOLOGY.

1. *Notice of Trilobites in the Cabinet of Dr. Julius S. Taylor*, (in a letter addressed by Dr. TAYLOR to the Editors.)—Believing that any information upon the subject of trilobites is at all times acceptable to the scientific world, I venture to tell you of a remarkable portion of one found a few days past by me. It is an "Isotelus megistos," and I think presents the most remarkable evidence of their gigantic size, of any specimen now extant. It was found in our blue limestone strata, and presents the tail or "post-abdomen," and seven of the segments across the back, nearly entire. Its width is 9¼ inches, and its length a little exceeds this. Thus you perceive, that if we had the other segment and the head, we should have one entire that would measure at least 18½ inches in length and 9¼ in breadth!

I see that Mr. Barrande of Prague is of the opinion that trilobites change greatly according to age. Of the correctness of that opinion I should have some doubts, as I have a variety of the Isotelus megistos from half an inch, up to the gigantic one above mentioned, and I find no difference in them either in proportions or segments, each having eight, and each portion being equal in length. I have also numerous specimens of the Calymene senaria, from the size of the smallest pea up to the size of one inch in width, and in them I find no difference. And

of several other varieties, I have many portions of different ages, all of which have exact resemblance. Of the Calymene Blumenbachii, I have them from one inch to three and a half in length, more or less perfect, and in them I find no change in appearance. Thus it would appear that in our varieties, at least, we have no metamorphosis of the earliest of the moving animals. However, I have not seen his work, and the notice of it may be too short to give a correct idea of what he means.

Carrolton, Montgomery Co., Ohio, April 18, 1850.

2. *Observations on the Mica Family;* by J. D. DANA.—The Mica family includes many distinct compounds formerly confounded, and the old names have on this account become inapplicable. The species *Oblique* or *Potash mica* is not the only oblique or potash mica, and some other appellation for this species has become necessary; and the writer has therefore adopted in his system of Mineralogy the name *Muscovite* from its common appellation, Muscovy glass. The other species have similar distinctive appellations, as *Biotite*, for hexagonal mica, *Phlogopite* for a trimetric mica, *Margarodite* for a second potash or oblique mica, etc.; and it is probable that several other species besides those now known, are yet to be distinguished.

The following observations on the different kinds of mica are mainly from the volume just referred to.

Rammelsberg in his 4th Supplement (p. 76) has calculated anew the several analyses of muscovite, and lays down the formulas of the varieties. But by some oversight, he makes the ratio for the oxygen of the protoxyds, peroxyds and silica, 1 : 12 : 15 equal to $\frac{3}{4}$: 9 : 12, as if 4 : 5 equals 3 : 4; and the formula deduced is that based on the former ratio. As the point is of some importance, we give here the ratios from his calculations, making the oxygen of the alumina 12, for better comparison with that of the silica as well as the protoxyds. A slight variation in the protoxyds, whether from impurity or not, varies largely the ratio to the other ingredients: while the ratio between the peroxyds and silica, since it is much nearer equality, is not liable to such fluctuations. The results are as follows:

	Ṙ	Ḧ	S̈i			
Utö, Rose,	1·63	18·62[a]	24·68	= 1·05	12	15·91.
Broddbo, Rose,	1·42	17·76	23·95	= 0·96	12	16·18.
Fahlun, Rose,	1·39	18·56	24·01	= 0·90	12	15·52.
Kimito, Rose,	1·56	18·54	24·09	= 1·01	12	15·59.
Ochotsk, Rose,	1·44	17·89	24·52	= 0·97	12	16·45.
Zsidovácz, Kussin,	1·71	17·93	24·97	= 1·14	12	16·71.
Mean, excluding the last,				0·98	12	15·93
Mean, including the last,				1·005	12	16·06

[a] Corrected.

The mean therefore of the five analyses from which Rammelsberg deduces his ratio is very closely 1 : 12 : 16, and if Kussin's analysis be added, it gives still more nearly this ratio; moreover, the separate analyses correspond more nearly with 1 : 12 : 16 than 1 : 12 : 15. Rose's formula $\dot{K}\,\ddot{S}i+4\ddot{A}l\,\ddot{S}i$, adopted by this author, is not therefore sustained by the analyses.

Neither does Kussin's analysis correspond to the ratio $1\frac{1}{3} : 12 : 15$, whence Rammelsberg derives incorrectly (but correctly from 1 : 9 : 12) the formula $\dot{K}\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i$, but more nearly to $1\frac{1}{3} : 12 : 16\frac{1}{2}$, though probably essentially 1 : 12 : 16, like the preceding.

A mica from Unionville, Pa., occurring in scaly granular masses, afforded J. D. Darrack, in the Laboratory of J. C. Booth, (Min., 1850, p. 357,)

$\ddot{S}i$ 46·75, $\ddot{A}l$ 39·20, $\dot{F}e$ *trace*, $\dot{M}g$ 1·02, $\dot{K}$ 6·56, $\dot{C}a$ 0·39, $\dot{H}$ 4·90 = 98·82.

This gives for the ratio 1·61 : 18·32 : 24·29 = 1·05 : 12 : 15·91 or nearly 1 : 12 : 16.

The Abborforss mica (Svanberg) and Fuchsite (Schafhäutl) afford,

Abborforss, 3·27 : 15·06 : 20·61 = 2·60 : 12 : 16·42 = $2\frac{2}{3}$: 12 : 16.
Fuchsite, 2·33 : 17·88 : 24·91 = 1·53 : 12 : 16·32 = $1\frac{1}{2}$: 12 : 16.

The first corresponds to the ratio 2 : 9 : 12, and formula $\dot{R}^2\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i$. Taking the Fuchsite at $1\frac{1}{3}$: 12 : 16, it gives the formula $\dot{R}\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i$.

MARGARODITE, *Schafhäutl.*—This pearly white biaxial mica and others allied have afforded the following analytical results.

Analyses : 1, Schafhäutl ; 2, Delesse, (Ann. d. Mines, [4], xvi, 202, 1849) ; 3, 4, Brewer, of the Yale Laboratory, (Min., 1850, 359) ; 5, Rammelsberg, (4th Supp., 75) :

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
1. Zillerthal,	47·05	34·90	1·50	—	1·95	4·07	7·96	1·45	=98·88, Schafhäutl.
2. St. Etienne,	46·23	33·08	3·48	*trace*	2·10	1·45	8·87	4·12, F *trace*	=99·33, D.
3. Monroe, Ct.,	49·96	32·85	*trace*	—	1·08	2·89	7·91	4·46[a], Cl 0·14	=99·29, B.
4. " "	49·97	32·60	—	—	1·41	*undetermined*	4·46[a],		Brewer.
5. Loc. doubtful,	47·84	32·36	3·06	—	1·28	1·55	10·25	2·43, $\dot{C}a$ 0·29	=99·06, R.

[a] A mean of 4 determinations.

The ratios are as follows,

1,	3·17 : 16·35 : 24·45 = 2·33 : 12 : 17·95 = 1·16 : 6 :	8·97
2,	2·65 : 16·46 : 24·02 = 1·98 : 12 : 17·51 = 0·99 : 6 :	8·76
3, 4,	2·63 : 15·35 : 25·96 = 2·05 : 12 : 20·29 = 1·02 : 6 :	10·14
5,	2·71 : 16·03 : 24·86 = 2·03 : 12 : 18·61 = 1·01 : 6 :	9·30

Rammelsberg and Delesse agree nearly in giving the ratio 1 : 6 : 9. Schafhäutl's has the protoxyds a little in excess, and Brewer obtained an excess of silica. But it is probable that all come under the same formula, $\dot{R}\,\ddot{S}i+2\dot{R}\,\ddot{S}i$. The mica of Monroe, Ct., occurs with fluor spar and topaz in large scales, aggregated into wedge shapes. G=2·79—2·81. The St. Etienne mica has G=2·817 ; Rammelsberg's 2·831 ; Schafhäutl's 2·872. In this species the oxygen ratio of the peroxyds and silica is 2 : 3, while it is 3 : 4 in muscovite. The *Gilbertite* of Thomson appears to be altered muscovite, or margarodite.*

---

* The mineral *Gilbertite* has the aspect of a pearly white mica, occurring in scales often radiately aggregated. The following are the analyses given ; 1, Lehunt, of true Gilbertite from Cornwall, (Thom. Min., i, 235) ; 2, Thomson, Cornwall, different locality.

	$\ddot{S}i$	$\ddot{A}l$	$\dot{M}g$	$\dot{C}a$	$\dot{F}e$	$\dot{N}a$	$\dot{H}$	
1.	45·15	40·11	1·90	4·17	2·43	—	4·25	=98·01, Lehunt.
2.	47·80	32·62	1·60	—	5·18	9·23	4·00	=100·43, Thomson.

The first analysis gives for the oxygen of the protoxyds, peroxyds and silica, 2·48 : 18·75 : 23·46, whence the ratio 1·59 : 12 : 15·01. Dufrenoy deduces 2 : 12 : 16. Like

PHLOGOPITE, (or Rhombic Mica) according to Meitzendorff's analyses has the ratio $1 : \frac{2}{3} : 1\frac{2}{3}$ and formula $3\dot{R}^3\ddot{S}i+2\dot{R}\ddot{S}i$, which is the formula of idocrase. Rammelsberg places here a mica from Sala analyzed by Svanberg. The species includes brown or yellowish coppery mica from Natural Bridge, Pope's Mills, Gouverneur, and Vrooman's Lake in northern New York; a black mica from Moriah, Essex Co.; a silvery mica from Edwards, N. Y.; a transparent mica from Pope's Mills, a variety of the brown. The optical character of these micas has been observed by the writer in connection with B. Silliman, Jr.

BIOTITE (Hexagonal or Magnesia Mica) has the ratio 1 : 1 : 2, and formula $\dot{R}^3\ddot{S}i+(\dot{A}l, \dot{F}e)\ddot{S}i$, which is essentially the formula of garnet. A chrome magnesia mica gives the ratio $\frac{1}{4} : 1 : 2$, but whether uniaxial or not is not certain. A Pargas biotite gives, $\frac{2}{3} : 1 : 2$, and the formula $\dot{R}^2\ddot{S}i+\dot{R}\ddot{S}i$ (Rammelsberg); and a Rosendal, $1 : 1 : 2\frac{1}{2}$, or the formula $3\dot{R}^2\ddot{S}i+2\dot{R}\ddot{S}i$.

LEPIDOLITE or Lithia mica.—The Lithia micas have been the subject of study by Rammelsberg, and he concludes that in them as well as topaz, the fluorine replaces oxygen, or is in the same state of composition as the oxygen. There are several distinct chemical compounds included, and it is not definitely known that they are all biaxial. Brewster observes that in one lithia mica part of the specimen was biaxial and part uniaxial. The ratios given by Rammelsberg are,

a. $1 : 3 : 6 = \dot{R}\ddot{S}i+\dot{R}\ddot{S}i$—mica of Ural, Chursdorf, Utö, Rozena, Altenberg (Stein).
b. $2 : 9 : 15 = 2\dot{R}\ddot{S}i+3\dot{R}\ddot{S}i$—mica of Zinnwald.
c. $1 : 2 : 5 = 3\dot{R}\ddot{S}i+2\dot{R}\ddot{S}i$—mica of Juschakowa.
d. $1 : 6 : 7 = \dot{R}^3\ddot{S}i+6\dot{R}\ddot{S}i$—mica of Altenberg according to Turner.

In the Ural, Chursdorf, Utö, and Rozena micas, the fluorine is to the oxygen as 1 : 20; in the Altenberg, (Stein), 1 : 60; in the Zinnwald, 1 : 14, or 1 : 11; in the Juschakowa, 1 : 8; in the Altenberg, (Turner), 1 : 25.

The Ural mica (Turner) affords then the formula,—writing for $\dot{R}\ddot{S}i+\dot{R}\ddot{S}i$, $(R\,O+Si\,O^3)+(R^2\,O^3+Si\,O^3)$,

$$20[(R\,O+Si\,O^3)+(R^2\,O^3+Si\,O^3)]+[(R\,F+Si\,F^3)+(R^2\,F^3+Si\,F^3)];$$

and in the same way the other formulas may be written out. Making O and F isomorphous, this formula becomes,

$$[R\,(O, F)+Si\,(O, F)^3]+[R^2(O, F)^3+Si(O, F)^3].$$

EMERYLITE and EUPHYLLITE.—These species have undergone recent re-examinations, and the species now stand as follows.

EMERYLITE, *J. Lawrence Smith.* Corundellite and Clingmanite, *Silliman*, Jr.—Foliated like mica; folia easily separable. Either in coarse plates or in masses consisting of aggregated spangles.

H.=3·5—4·5. G.—2·995, Silliman, Jr. Lustre pearly. Color white. Translucent, to nearly opaque. Folia brittle or slightly flexible.

---

muscovite the protoxyds bear a small proportion to the peroxyds, and the ratio is very near that derived from some analyses of this species. The specimens look like a slightly altered mica. Including the water, the oxygen ratio is 1·59 : 12 : 15·01 : 2·41. The oxygen ratio for the second analysis is 4·16 : 15·24 : 24·84=1·64 : 6 : 9·78, approaching margarodite, excepting in the larger amount of protoxyds.

The relation of the species to the micas is evident; yet other analyses are desirable.

Composition.—$\dot{R}^3\ddot{S}i+3\dot{A}l^2\ddot{S}i[+3\dot{H}]$=Silica **30·58**, alumina **50·99**, lime **13·96**, water **4·47**. Analyses: **1**, J. Lawrence Smith, (Am. J. Sci. [2], vii, 285); **2, 3, 4**, Wm. J. Craw, in the Yale Laboratory, (Silliman, Jr., Am. J. Sci. [2], viii, 379); **5, 6**, ibid, (private communication); **7**, C. Hartshorne, in Laboratory of J. C. Booth, (private communication from Prof. J. C. Booth); **8**, Silliman, Jr., (private communication):

	$\ddot{S}i$	$\dot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
1. Asia Minor,	30·	50·	13·	—	—	—	—	$\dot{F}e$, $\dot{M}n$, $\dot{K}$ 3, $\dot{Z}r$ 4=100, S.
2. Village Green,	32·31	49·24	10·66	0·30	2·21	(loss)	5·27	=100, Craw.
3. "	31·06	51·50	9·24	0·28	2·97	"	5·27	=100, Craw.
4. "	31·26	51·60	10·15	0·50	1·22	"	4·27	=100, Craw.
5. "	30·18	51·40	10·87	0·92	2·23	0·54	4·52	=100, Craw.
6. Unionville,	29·99	50·57	11·31	0·62	1·62	0·85	5·14	=100, Craw.
7. "	32·15	54·28	11·36	0·05	*undetermined*	0·50,	$\dot{F}e$ *trace*,	Hartshorne.
8. North Carolina,	29·17	48·40	9·87	1·24	6·15	—	3·99,	HF 2·03=100·80, S. Jr.

Analyses **6, 7** are of the *Corundellite*, and **8**, of the *Clingmanite*. The following are the oxygen ratios for the protoxyds, peroxyds, and silica:

	$\dot{R}$		$\dot{R}$		$\ddot{S}i$					
1.	4·20	:	24·42	:	15·59	=	1·08	:	6·26	: 4
2.	3·87	:	23·01	:	16·79	=	0·99	:	5·48	: 4
3.	3·43	:	23·93	:	16·14	=	0·85	:	5·93	: 4
4.	3·40	:	24·12	:	16·24	=	0·85	:	5·94	: 4
5.	4·03	:	24·02	:	15·68	=	1·03	:	6·13	: 4
6.	4·01	:	23·64	:	15·53	=	1·17	:	6·08	: 4
7.	3·65[a]	:	25·37	:	16·71	=	0·92	:	6·08	: 4
8.	3·99	:	23·92	:	15·84	=	1·08	:	6·04	: 4
					Mean		=1·00	:	5·99	: 4

[a] Supposing the alkalies equivalent to the loss.

The mean result is quite closely **1 : 6 : 4**, and the same is afforded by several of the particular results. As Dr. Smith found no water, and Hartshorne only **0·5** per cent., the species is primarily anhydrous. Including the water found by Craw in his specimens, the ratio is **1 : 6 : 4 : 1**.

Commonly yields water in a matrass, with sometimes a trace of fluorine. B.B. exfoliates and emits a bright light and finally fuses on the edges.

Detected by Dr. J. Lawrence Smith, with the corundum of Magnesia, Asia Minor, and also at Naxia and Niconia. Also found with corundum at Village Green, Delaware Co., Pa.; at Unionville, Chester Co., Pa., (Corundellite); at the Corundum locality in Buncombe Co., North Carolina, (Clingmanite).

EUPHYLLITE, *Silliman*, Jr.—Structure as in common mica, but laminæ not as easily separable. Biaxial; angle between the optical axes 71½°, Silliman, Jr.

H.=3·5—4·5. G.=2·963—3·008. Lustre of cleavage surface bright pearly, inclining to adamantine. Color white to colorless; sides faint grayish sea-green or whitish. Transparent to translucent; at times opaque or nearly so. Laminæ rather brittle.

Composition.—Analyses: **1, 2**, H. Erni, in the Yale Laboratory, (private communication); **3, 4**, T. Garrett, in J. C. Booth's Laboratory, Philadelphia, (private communication):

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$	
1. Unionville,	43·69	44·69	—	3·98	0·75	0·98	0·82	5·60	=100·41, Erni.
2. "	43·45	44·98	—	4·34	0·69	*undetermined*		4·97,	Erni.
3. "	45·93	48·23	0·60	3·53	2·44	—	*trace*	—	=100·73, Garrett.
4. " (dif. loc.)	45·33	46·47		2·36	*trace*	—	*undet.*	—	, Garrett.

The following are the oxygen ratios for the analyses:

1.	1·80	:	20·88	:	22·65	=	0·95	: 11·06	: 12
2.	1·88	:	21·02	:	22·57	=	1·00	: 11·18	: 12
3.	1·96	:	22·82	:	23·87	=	0·98	: 11·47	: 12
4.	—	:	21·72	:	23·55	=	—	: 11·07	: 12
					Mean,		0·98	: 11·19	: 12

The ratio 1 : 11 : 12 appears therefore to be that authorized by the analyses. As no water was found in the 3d and 4th analyses, the species is essentially anhydrous. Including the water found by Erni, the ratio becomes 1 : 11 : 12 : 3, and the formula $\dot{R}^3\,\ddot{S}i+11\dot{A}l\,\ddot{S}i+9\dot{H}$.

It is still possible that 1 : 12 : 12 will prove to be the true ratio; and in that case the ratios for margarite, emerylite, euphyllite, and muscovite, have an obvious simple relation, they being respectively 1 : 12 : 8: 2 : 12 : 8; 1 : 12 : 12; 1 : 12 : 16.

In a matrass, often yields water. B.B. exfoliates, emits a strong light, and in the forceps fuses on the edges. Gives traces of fluorine, but none of lithia.

Occurs associated with tourmaline and corundum at Unionville, Delaware Co., Pennsylvania. The impression of the crystals of tourmaline on the lateral surface of the mica, leaves a very smooth, hard looking surface. Also in the same vicinity in aggregated laminæ, or scales; this variety afforded the analysis No. 4 above.

Recapitulation.—The following are the oxygen ratios observed among the micas, and the formulas corresponding:—

(1.) Micas having atomically as much alumina as silica, or a larger amount. These micas are harder than those of the following division, and brittle or but slightly elastic.

1. *Margarite,*	1	: 12	: 8 = 1	:	12	: 8	$\dot{R}^3\,\ddot{S}i^2+6\dot{A}l^2\,\ddot{S}i$
2. *Emerylite,*	2	: 12	: 8 = 1	:	6	: 4	$\dot{R}^3\,\ddot{S}i+3\dot{A}l^2\,\ddot{S}i.$
3. *Euphyllite,*	1	: 12 (?11)	: 12				$?\dot{R}^3\,\ddot{S}i+11\dot{R}\,\ddot{S}i.$

(2.) Micas having atomically less alumina than silica

1. *Muscovite, a.*	1	: 12 : 16	= 1 : 12	: 16	$3\dot{R}, 12\dot{A}l, 16\ddot{S}i.$
b. Fuchsite,	$1\frac{1}{2}$	: 12 : 16	= 1 : 8	: $10\frac{2}{3}$	
c. Abborforss,	$2\frac{2}{3}$	: 12 : 16	= 1 : $4\frac{1}{2}$	: 6	$\dot{R}^2\,\ddot{S}i+3\dot{A}l\,\ddot{S}i.$
2. *Margarodite,*	2	: 12 : 18	= 1 : 6	: 9	$\dot{R}\,\ddot{S}i+2\dot{A}l\,\ddot{S}i.$
3. *Lepidolite, a.*	4	: 12 : 24	= 1 : 3	: 6	$\dot{R}\,\ddot{S}i+\dot{R}\,\ddot{S}i.$
b.	$2\frac{2}{3}$	: 12 : 20	= 1 : $4\frac{1}{2}$	: $7\frac{1}{2}$	$2\dot{R}\,\ddot{S}i+3\dot{R}\,\ddot{S}i.$
c.	6	: 12 : 30	= 1 : 2	: 5	$3\dot{R}\,\ddot{S}i+2\dot{R}\,\ddot{S}i.$
d.	2	: 12 : 14	= 1 : 6	: 7	$\dot{R}^3\,\ddot{S}i+6\dot{R}\,\ddot{S}i.$
4. *Phlogopite,*	18	: 12 : 30	= 1 : $\frac{2}{3}$	: $1\frac{2}{3}$	$3\dot{R}^3\,\ddot{S}i+2\dot{R}\,\ddot{S}i.$
5. *Biotite, a,*	12	: 12 : 24	= 1 : 1	: 2	$\dot{R}^3\,\ddot{S}i+\dot{R}\,\ddot{S}i.$
b, Pargas,	8	: 12 : 24	= 1 : $1\frac{1}{2}$	: 3	$\dot{R}^2\,\ddot{S}i+\dot{R}\,\ddot{S}i.$
c, Chrome,	6	: 12 : 24	= 1 : 2	: 4	$\dot{R}^3\,\ddot{S}i^2+2\dot{R}\,\ddot{S}i.$
d. Rosendal,	(?) 12	: 12 : 30	= 1 : 1	: $2\frac{1}{2}$	$3\dot{R}^2\,\ddot{S}i+2\dot{R}\,\ddot{S}i.$
6. Chamouni, Delesse,	(?) $4\frac{4}{5}$	: 12 : $19\frac{1}{5}$	= 1 : $2\frac{1}{2}$	: 4	$3\dot{R}^2\,\ddot{S}i+5\dot{R}\,\ddot{S}i.$
7. *Lepidomelane,*	4	: 12 : 16	= 1 : 3	: 4	$\dot{R}^3\,\ddot{S}i+3\dot{R}\,\ddot{S}i.$

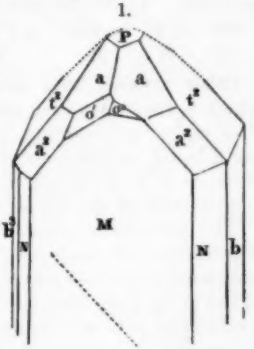
The mineral *Diphanite*, resembles margarite and euphyllite, according to Breithaupt. It has the ratio $1 : 4\frac{1}{2} : 3\frac{3}{4}$ or $2\frac{2}{3} : 12 : 10$.

We have not written a formula for the muscovite. It is evident from a survey of the compounds, that there must be some more satisfactory mode of exhibiting the relations of substances, than by the formulas often made out. They frequently make seeming diversity instead of showing relationships, and tend to mislead the eye not thoroughly acquainted with the wide variation of formula consequent on a slight change of ratio.

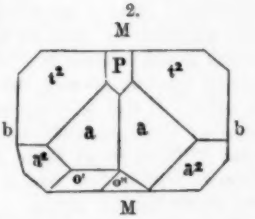
The amount of water which analyses afford varies from 0 to 5 per cent.; and as it exists variously or not at all, in micas in which the oxygen ratio is the same, there is reason for believing it the result of a partial alteration of the mica, like that which takes place in iolite. The hydrous varieties are commonly more or less wanting in transparency.

3. *Spodumene*, (Dana's Min., 1850, p. 693.)—The annexed figure of a crystal of Spodumene, from Norwich, Mass., has been made by the author from a specimen belonging to Mr. Charles Hartwell. Mr. Hartwell had measured the angles, and presented a notice of the crystal to the meeting of the American Scientific Association at Cambridge, in 1849. On examination, the author finds that the crystal is monoclinic, and further that Spodumene is actually isomorphous with Pyroxene. The annexed figure represents the crystal as it is, with a vertical plane b^3 on the right and the corresponding one on the left wanting, and also with the two planes o'' and o' unmated; moreover the back planes of the summit are absent, as the crystal is not entire or is broken on that part. The edge of intersection of o' and o'' is uncertain, as the surface has been abraded. But the rest of the faces figured are smooth, though not bright. The direction of the intersections as seen in a vertical view are shown in figure 2; the edge between o' and a^2 has a parallel direction with that between a and t^2, but that between o' and o'' is doubtful. The crystal is $2\frac{1}{4}$ inches long, $1\frac{5}{8}$ inches wide, and 1 inch thick. The color is grayish, with a tinge of green. Besides the usual cleavages—the orthodiagonal perfect, and the prismatic scarcely less so—there are distinct traces of cleavage parallel to each orthodiagonal edge of the pyramid a—a direction pointed out on the figure by the dotted line on plane M. The surface of plane M moreover is very finely crossed by lines corresponding to this cleavage direction. The crystal is bisected along its orthodiagonal section, and on holding one of the halves up to the light it is seen to be translucent, and marked throughout with the same lines as on the surface.

1.



2.



The following are the angles, as observed with the common goniometer by Mr. Hartwell and by the author.

	Hartwell.	Author.
N : N	87°	87°
N : N (lateral angle)	93°	93°
N : M	133°	133° 30′
N : b	137°	136° 30′
N : b^3	153°	154°
M : b^3		107°
M : t^2		106°—107°
M : P		69° 40′
M : a	100° 30′	100° 30′
M : a^2	116°	116°
M : o′		127°
M : o″		140°
t^2 : t^2 (over P)		79° 30′
t^2 : b	140°	139° 45′
a^2 : t^2		140° 30′
a : a (front)	117°	117°

The crystallographic expressions for the planes are indicated in the lettering, except for the planes o′, o″, which are not determinable with certainty. In Naumann's system of notation they are:—

0P	∞P	∞P∞	∞P′∞	∞P3	P	2P	2P′∞	3P3?	mPn
P	N	M	b	b^3	a	a^2	t^2	o′	o″

Other crystals have since been obtained by Mr. Hartwell, one of which is six inches long and nearly half this in breadth. The planes P, o′ and o″ are wanting, and the back edge of the plane t^2 is straight, there being no plane—m P. The complete description of the crystal is hence ∞P, ∞P∞, ∞P′∞, ∞P3, P, 2P, 2P′∞. The plane ∞P3 is seen only on the left side of plane M, as in the figure.

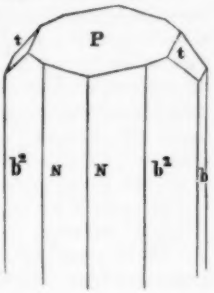
The specimens afforded B. Silliman, Jr., a strong lithia reaction.* These facts set aside an idea adopted by Dufrénoy and Pelouze, and becoming somewhat prevalent, that spodumene is a lithia feldspar; and at the same time they fail to sustain the suggestion of the writer, that spodumene is related to andalusite. The formula of spodumene best expressing its composition as ascertained by analysis, is $\dot{R}^3\ddot{S}i^2+4\ddot{A}l\ddot{S}i^2$ (Kobell). And if we consider the protoxyds and peroxyds as replacing one another, we find 15 of oxygen in the oxyds to 30 in the silica, which is the relation in pyroxene. With the above formula, and 3·17 for the specific gravity, the A atomic volume is 2852; the B, 168; the C, 43·2. It will be observed that 43·2 is only as much smaller than the number for pyroxene† as it is larger than that for andalusite. Moreover 2852 is about *three times* the corresponding number for hornblende, *four* to *four and a half* times that of pyroxene and its varieties, and *twice* that of borax.

* The spodumene of Conway, Mass., in the same range, was tested for lithia successfully by G. T. Bowen, in 1824, and analyzed so far as to obtain $\ddot{S}i$ 65·3, $\ddot{A}l$ 24·5, which agrees with the usual analyses of the species.—*This Journal*, 1824, *viii*, 120, 121.—The specific gravity of the Norwich spodumene according to a recent determination by G. J. Brush, is 3·18.

† See this Journal, last volume, pp. 241, and 429.

4. *Anhydrous Prehnite.*—The Anhydrous Prehnite of J. D. Whitney, (Bost. Jour. Nat. Hist., v, 487,) has been examined by Dr. C. T. Jackson, and found to contain the same per-centage of water as prehnite. In his trials he found 4·7 and 4·15 per cent. of water, and subsequently, 4·18, 4·45, 4·50, 4·41 per cent. Other specimens examined by Mr. G. J. Brush in the Yale Laboratory, afforded 4·913, 4·817, 4·864 per cent. This mineral appears therefore to be identical with ordinary prehnite. The existence of water in this variety was first ascertained in a blowpipe experiment by Mr. J. E. Teschemacher of Boston.

5. *On a new crystalline form of Staurotide, and Isomorphism of Staurotide with Andalusite and Topaz*; by J. D. DANA.—The accompanying figure represents crystals of staurotide from the spodumene locality, Norwich, Mass., which were obtained by Mr. C. Hartwell. The faces are smooth excepting sometimes t and P. The angles obtained with the common goniometer are as follows:—



N : N = 129° 20′
b² : b² (over N) = 93°
N : b² = 162°
P : t = 131° (129° – 132°)

The crystals are black and semi-metallic in lustre. The largest are 1½ inches in breadth.

The isomorphism of this species and andalusite is sufficiently close to merit attention.

Calculating from N : N = 129° 20′, the prism b² = 93° 8′. In Andalusite, the prism corresponding to the latter is 91° 20′, and this gives for the former 127° 57′. P : t in Staurotide = 131°, in andalusite 144° 50′; and the planes have therefore the axial relation of 3 : 2.

For the relation of topaz and andalusite, see last volume of this Journal, p. 407.

The atomic volume of the St. Gothard staurotide, calculated from one of Jacobson's analyses corresponding to $(\frac{4}{5}\dot{\mathrm{A}}\mathrm{l}+\frac{1}{5}\dot{\mathrm{F}}\mathrm{e})^2\,\ddot{\mathrm{S}}\mathrm{i}$, and specific gravity 3·74, gives for the A atomic volume 536, and for the C atomic volume 38·3: for a St. Airolo staurotide, with the formula $(\frac{4}{5}\dot{\mathrm{A}}\mathrm{l}\dagger\frac{1}{5}\dot{\mathrm{F}}\mathrm{e})^3\,\ddot{\mathrm{S}}\mathrm{i}^2$, and specific gravity 3·7, we obtain the A atomic volume 890·5, the C value 38·7. Andalusite afforded (last volume of this Journal, p. 235) A = 962·5, C = 41·85; and topaz (loc. cit., p. 240) A = 2344; B = 42·6.

6. *Platinum of California.*—In a letter from J. E. Teschemacher, we are informed that he has detected a proportion of platinum among the grain gold of California, that will render it an important object of search in that region. In an ounce of the fine grains, he found about 50 granules which proved to be this metal. He observes that the proportion obtained is about as large as from the South American mines.

7. *Fowlerite.*—This name, applied to a variety of manganese spar or rhodonite, was not originally proposed by Prof. Shepard, as stated on p. 410 of last volume of this Journal.

III. Zoology.

1. *Remark on the Genus Nocticula of J. V. Thompson;* by J. D. Dana. —The genus Nocticula established by Thompson in his Zoological Researches, No. 2, p. 52 and plate 5, (Cork, 1829,) is closely related to the Euphausidæ.* The general form of the animal, its thoracic and abdominal appendages, and the antennæ, eyes, and short beak, are as in Thysanopoda and Euphausia; and the last abdominal segment has the acuminate character with the naked barb either side near apex, which occurs in this family.† The legs are not however represented as bifid, the outer branch and branchial appendages having been overlooked, (and in the suggestion of this error we make the "*due allowance* for drawings made at sea of such minute objects" which Thompson asks of his readers.) The number of thoracic legs is stated at sixteen, but this includes, as the drawing shows, a pair of maxillipeds. Excluding these, there will then be 7 pairs, which is the number in Thysanopoda; and it seems probable that Nocticula and Thysanopoda are identical, and if so, the former name has the precedence.

The species described and figured by Thompson, was taken in the Atlantic, between latitudes 5° 25′ S., and 29° 30′ N., and longitude 17° 18′ W., and 32° 55′ W., on the 6th, 12th, and 25th of September. It was brilliantly phosphorescent. It is called the *Nocticula Banksii*, as it is supposed by Thompson, and with apparent good reason, to be identical with the *Cancer fulgens* of Sir Joseph Banks, a species observed between Madeira and Brazil, and published with a drawing by Macartney in the Philosophical Transactions for 1810. This drawing, Thompson has copied, and in it 7 pairs of thoracic legs are represented.

2. *Observations on some Crustacea, in the collections of the Academy of Natural Sciences at Philadelphia;* by Prof. L. R. Gibbes of Charleston, S. C., (Proc. Acad. Nat. Sci., Philad., March, 1850, v, 25.)—The *Chorinus armatus* of Randall (Memoir in Jour. Ac. Nat. Sci. Philad., viii, 106,) is a Pericera, and agrees with *Pericera cornuta* of Edwards, (Crust., i, 335.)

The *Cancer mercenaria* of Say, is a *Pseudocarcinus*. It is referred by Edwards with some doubt to the genus Xantho of Leach (M. Edw., Crust., i, 399); but his description of *Pseud. ocellatus* applies in every particular to the *mercenaria*.

Grapsus longipes, *Randall*, is *Grapsus cruentatus*, according to Gibbes, and the statement that Surinam is its locality, is considered a mistake.

Grapsus hirtus, *Randall*, is *G. rudis*, M. Edw., the latter name having the priority.

Guaia ornata, *Randall*, is an *Ilia*, and a distinct species.

To the above, the Committee of the Society add—that *Macrophthalmus compressipes*, Randall, (published in 1840,) is *Gelasimus telescopicus*, Owen, Voyage of Blossom (1839), and *M. podophthalmus*, Voyage of Bonite, (1841.)

Pachygrapsus parallelus, *Randall*, is *Grapsus Thukujar*, Owen, loc. cit.; and Pagurus decorus, Randall, is *P. pictus*, Owen.

---

* See this Journal, [2], ix, p. 130.

† Milne Edwards alludes to this character in the name of his Thysanopoda, *T. tricuspidata*. Ann. des Sci. Nat., xix, 1830, 454, note.—The genus Nocticula is not referred to by Edwards, either in his Memoir, or in his Hist. Nat. des Crustacés.

In most of these cases in which Dr. Randall has been forestalled, it has been by publications that were not through the press when his memoir was in course of preparation.

3. *Conspectus Crustaceorum quæ in Orbis Terrarum circumnavigatione*, CAROLO WILKES *e Classe Reipublicæ Fœderatæ Duce, lexit et descripsit* J. D. DANA. AMPHIPODA, No. I. (Proc. Amer. Acad. Arts and Sciences, ii, 201).—The following are the names of the sixty-two new species described in this paper.

Familia 1. *Orchestidæ* :—

Genus I. TALITRUS: *species*, novi-zelandiæ, gracilis, ornatus.

Genus II. TALITRONUS, (*Dana*): *species*, insculptus.

Genus III. ORCHESTIA: *species*, sylvicola, tenuis, rectimanus, spinipalma, scutigerula, nitida, dispar, quadrimanus, serrulata.

Genus IV. ALLORCHESTES, (*Dana*): *species*, compressa, verticillata, hirtipalma, gracilis, peruviana, humilis, australis, brevicornis, novizelandiæ, intrepida, orientalis, graminea.

Familia 2, *Gammaridæ*, Sub-familia 1, *Lyssianassinæ* :—

Genus I. LYSIANASSA: *species*, brasiliensis

Genus II. URISTES, (*Dana*): *species*, gigas.

Genus III. STENIA, (*Dana*): *species*, magellanica.

Familia 2. *Gammaridæ*, Sub-familia 2, *Gammarinæ* :—

Genus I. GAMMARUS: *species*, asper, suluensis, albidus, hirsuticornis, emissitius, tenuis, furcicornis, tenellus, orientalis, quadrimanus, validus, setipes, pilosus.

Genus II. AMPHITOË: *species*, peculans, fissicauda, pubescens, inæquistylis, peruviana, tenuicornis, indica, rubella, fucorum, tongensis, peregrina, brevipes, simplex, nodosa.

Genus III. ŒDICERUS: *species*, novi-zelandiæ.

Genus IV. ERICHTHONIUS: *species*, macrodactylus, pugnax.

Familia 3. *Corophidæ* :—

Genus I. COROPHIUM: *species*, quadriceps.

Genus II. CLYDONIA, (*Dana*): *species*, gracilis, longipes.

Familia 4, *Icilidæ* :—

Genus ICILIUS, (*Dana*): *species*, ovalis.

4. *Oithona plumifera of W. Baird.*—The genus Scribella described in this Journal, 2nd ser., i, 227, 1846, and also viii, 279, is identical with *Oithona* of Baird, published in 1843 in the Zoologist, and the *Scribella scriba* appears to be the same species with the *Oithona plumifera*. J. D. D.

5. *On the circulation and digestion in the lower Animals;* Prof. AGASSIZ, (Proc. Bost. Soc. Nat. Hist, 1850, p. 206.)—Prof. Agassiz read a paper on the circulation and digestion in the lower animals, showing that the circulation in the Invertebrata cannot be compared to that of the Vertebrata.

Instead of the three conditions of chyme, chyle, and blood, which the circulating fluid of the Vertebrata undergoes, the blood of that class of the Invertebrata, which he had particularly studied, the Annelida, is, according to Wagner, simple chyle, colored chyle; the receptacles of chyle in different parts of the body are true lymphatic hearts like those found in the Vertebrata; this kind of circulation is found in the Articulata and

Mollusks with few exceptions, some Echinoderms, &c. In the Medusæ and Polyps, instead of chyle, chyme mixed with water is circulated: this circulation is found in some Mollusks and intestinal worms; it may be seen plainly in Beroë. Prof. Agassiz thinks that the embryological development of the higher animals shows a similar succession in the circulating function. He also examined the connection of respiration with the circulation: in Vertebrata, the gills are found between branches of the blood system; in Invertebrata, the chyliferous system is acted on by the respiration; the gills of fishes, then, cannot be compared to the gills of Crustacea, Articulata and Mollusks. No gills are connected with the chymiferous circulation; animals having this circulation have no true respiration; they have only tubes to distribute freely aërated water to the different parts of the body.

6. *Low State of Development of Mammals and Birds in Australia and New Zealand*, (Gould's Birds of Australia; Jameson's Jour., xlviii, 362.)—Geological researches into the structure of the globe, shew that a succession of physical changes have modified its surface from the earliest period up to the present time, and that these changes have been accompanied with variations not only in the phases of animal and vegetable life, but often in the development also of organization: and as these changes cannot be supposed to have been operating uniformly over the entire surface of the globe in the same periods of time, we should naturally be prepared for finding the now existing fauna of some regions exhibiting a higher state of development than that of others; accordingly, if we contrast the fauna of the old continents of geographers with the zoology of Australia and New Zealand, we find a wide difference in the degree of organization which creation has reached in these respective regions. In New Zealand, with the exception of a *Vespertilio* and a *Mus* which latter is said to exist there, but which has not yet been sent to this country, the most highly organized animal hitherto discovered, either fossil or recent, is a bird; in Australia, if compared with New Zealand, creation appears to have considerably advanced, but even here the order *Rodentia* is the highest in the scale of its indigenous animal productions; the great majority of its quadrupeds being the Marsupiata (kangaroos, &c.) and the *Monotremata*, (*Echidna*, and *Ornithorhynchus*), which are the very lowest of the Mammalia; and its ornithology being characterized by the presence of certain peculiar genera, *Talegalla*, *Leipoa*, and *Megapodius;* birds which do not incubate their own eggs, and which are perhaps the lowest representations of their class,* while the low organization of its botany is indicated by the remarkable absence of fruit bearing trees, the *Cerealia*, &c.

---

* The genera, *Talegalla*, *Leipoa*, and *Megapodius*, form part of a great family of birds inhabiting Australia, New Guinea, Celebes, and the Phillippine Islands, whose habits and economy are most singular, and differ from those of every other group of birds which now exist upon the surface of the earth. In their structure they are most nearly allied to the *Gallinaceæ*, while in some of their actions, and in their mode of flight, they much resemble the *Rallidæ;* the small size of their brain, coupled with the extraordinary means employed for the incubation of their eggs, indicates an extremely low degree of organization.

The three species of the family inhabiting Australia, although referable to three distinct genera, have many habits in common, particularly in their mode of nidifica-

7. *New Species from Lake Superior described by M. Agassiz.*—The interesting and valuable volume lately issued by Prof. Agassiz and his associates, contains descriptions of numerous new forms of animals. We now enumerate the following species of fish described for the first time by Prof. Agassiz in this volume.

Acipenser lævis, Agass., p. 267.

" *carbonarius*, Agass., p. 271, (Plate 5, fig. 1.)

" *rhynchæus*, Agass., p. 276.

Pimelodus felis, Agass., p. 281.

PERCOPSIS, Agass., new genus. We quote the remarks of Prof. Agassiz in full respecting the very remarkable new genus of fish to which he has assigned the name *Percopsis*.

"In order fully to understand and perfectly to appreciate the characters of this genus, and the interest involved in its discovery, it is necessary to remember various relations of the different types of the whole class, which however do not constitute generic distinctions, although they bear upon the peculiarities of this new type.

"In the first place, it is a matter of no little importance that, among the fishes of former ages, we find everywhere types which differ widely from the forms of our time, and that those forms are the more different, as they belong to older geological deposits. The differences are even so great, that out of the four orders of this class, there are only two which constitute the fauna of fishes in the older formations; two orders, which in our day are comparatively reduced, I mean the Placoids and Ganoids. Moreover, the types are peculiar in all epochs. For instance, the sharks of former days, especially those of older epochs, resemble solely that curious genus of Port Jackson, New Holland, the Cestracion, which is so remarkable among the living fishes as to form a group by itself. The Ganoids, of which there are so remarkably few in the present creation, such as the gar-pike (Lepidosteus) of this continent, are not less peculiar, and in connection with those ancient Placoids, constitute the only representatives of the class of fishes throughout the earliest geological ages down to the deposits of the chalk, when new families of other orders, the Ctenoids and Cycloids, begin to make their appearance, preparatory as it were to the present development of that class, and are successively diversified with the modified adaptations of the whole class. Now the genus Percopsis is as important to the understanding of the modern types of fishes as Lepidosteus and Cestracion are to the understanding of the ancient ones, as it combines characters which in our day are never found together in the same family of fishes, but which in more recent geological ages constituted a striking peculiarity of the whole class. My Percopsis is really such an old-fashioned fish, as it shows peculiarities which occur simultaneously in the fossil fishes of the chalk epoch, which however soon diverge into distinct families in the tertiary period, never to be combined again.

---

tion, each and all depositing their eggs in mounds of earth and leaves, which, becoming heated either by the fermentation of the vegetable matter, or of the sun's rays, form a kind of natural hatching apparatus, from which the young at length emerge fully feathered, and capable of sustaining life by their own unaided efforts.

"This ancient character of some of the American fishes agrees most remarkably with the peculiarity of the vegetation of this continent, which, as I have shown on former occasions, resembles also the fossil plants of prior ages.

"The geographical range of these peculiar, old-fashioned beings is also very remarkable, they living in temperate, or rather cold climates, when their earlier representatives lived in warmer epochs.

"The most striking features of the fishes of the tertiary period and those of our time consist in their belonging to two groups of the class only; one, the Ctenoids, with rough, combed scales, in which the respective representatives have also prominent serratures on prominent spines upon the head, in the operculum in particular, and in the fins; the other, the Cycloids, smooth, with simple scales with an entire margin, in which some few types however have also spinous fins.

"Now my new genus, Percopsis, is just intermediate between Ctenoids and Cycloids; it is, what an ichthyologist, at present, would scarcely think possible, a true intermediate type between Percoids and Salmonidæ.

"The general form of this genus reminds us of the common perches, but it is easily distinguished from them, by the fact that its head and the opercular apparatus are smooth and unprovided with denticulations, as also by the presence of a small adipose fin, as in the salmons. The anterior dorsal is also a small fin, composed of soft branched articulated rays, as in the salmons. The ventral fins are placed at the middle of the abdominal cavity, as in the Abdominales in general. The scales, however, are truly serrated as in the Percoids, a structure which, as far as I know, does not occur in any of the Abdominales. The conformation of the mouth is also as in the Perches, that is to say, the intermaxillaries form alone the upper margin of the mouth, and the maxillaries stand behind as a second arch, but the vomer and palate are entirely destitute of teeth.

"This fish, of which I shall publish a full anatomy, should be considered as the type of a distinct family, under the name of *Percopsides*."

Species *Percopsis guttatus*.

The other new species described are:—

Grystes fasciatus, p. 295.
Cottus Richardsoni, p. 300.
Cottus Franklini, p. 303.
Boleosoma maculatum, p. 305, plate iv, fig. 3.
Pileoma zebra, p. 308.
Gasterosteus nebulosus, p. 310, pl. iv, fig. 4.
Gasterosteus pigmæus, p. 314, pl. iv, fig. 1.
Esox Boreus, p. 317.
Lota maculosa, p. 325.
Salmo Siscowet, p. 333, pl. i, fig. 3.
Coregonus sapidissimus, p. 344.
Coregonus latior, p. 348.

Rhinichthys, Agass., new genus. This new genus contains small Catostomi whose essential character is as the name indicates, to have a conical prolongation of the rostrum.

Rhinichthys marmoratus, p. 354, pl. ii, figs. 1 and 2.
Catostomus Forsterianus, p. 358.
" *Aurora*, p. 360, pl. ii, figs. 3 and 4.
Alburnus rubellus, p. 364, pl. iii, figs. 1–3.
Gobio plumbeus, p. 366.
Leuciscus frontalis, p. 368, pl. iii, fig. 4.
" *gracilis*, p. 370.

Besides the above, the work contains descriptions of three reptiles by Agassiz, *Hylodes maculatus*, *Rana nigricans*, and a species of *Crotophorus*; of numerous new Coleoptera by Prof. John L. Le Conte, besides a full catalogue of the species obtained, with various observations; a catalogue of the shells, with descriptions of some species; a catalogue of the birds, by J. E. Cabot; descriptions of some new Lepidoptera, by T. W. Harris.

IV. Miscellaneous Intelligence.

1. *Prof. C. U. Shepard, on Meteorites.*—We have received from the author the following abstract of Prof. Shepard's report on Meteorites, read before the American Association for the Promotion of Science, at their March meeting in Charleston, S. C. He first described a very peculiar meteoric stone which was seen to fall at Richland, South Carolina, during a violent thundergust in the summer of 1846. The stone was almost perfectly round, $2\frac{1}{10}$ inches in diameter, and weighed $6\frac{1}{2}$ oz. The exterior was coated by a dark reddish brown glaze. The interior presented the fracture and color of ordinary fire-brick. Sp. gr. 2·32. It consisted of

Silica, ...	80·420
Alumina, ...	15·680
Protox. iron, ...	2·513
Magnesia, ...	0·700
Lime, ...	0·500
	99·813

No examination was made for alkalies.

Prof. S. next described the recently fallen stone of Cabarras County, N. C., (Oct. 31, 1849,) of which some account has already been given in this Journal.* The entire stone (now weighing $18\frac{1}{2}$ lbs.) was exhibited to the meeting. The general figure is that of a low, irregular, four-sided pyramid, truncated at the summit, and having for a base (which is by far the broadest plane) a somewhat rounded, undulatory surface. The crust is thin, black and strongly coherent. It is exceedingly tough; in this respect fully equalling most trappean rocks. Its ground color is of a dark bluish-grey, stained with fine rust points, and mottled with rounded grains and crystals of a lighter colored mineral, rendering the mass when closely viewed, sub-porphyritic. It resembles in structure most nearly, the rare stone which fell at Tabor in Bohemia, July 3d, 1753. Sp. Gr. = 3·60...3·66.

* [2] Vol. ix, p. 143.

It consists of

Nickeliferous iron, (with chromium,) . . .	6·320
Magnetic pyrites, ...	3·807
Silica, ...	56·168
Protoxyd iron, ...	18·108
Magnesia, ...	10·406
Alumina, ...	1·797
	96·606
Traces of lime, soda, potassa and loss,	3·394
	100·000

He concluded his contributions to American localities by a description of the meteoric iron of Ruff's mountain, Newberry, S. C., lately brought to light by Dr. Wells of New Haven. In noticing the internal structure of this beautiful iron, Prof. S. remarked that it resembled those of Texas and Carthage, Tenn., more closely than any others with which he was acquainted, although it differed from these by presenting here and there small gashes or veins filled with a very peculiar pyrites which may prove a new meteoric species. Sp. Gr. of internal portions of the mass =7·01...7·10; of exterior (where it is mingled with magnetic oxyd of iron) 5·97...6·80. Composition,

Iron, ...	96·000
Nickel, ...	3·121
Chromium, sulphur, cobalt, magnesium and chlorine,	traces.
	99·121

The report was concluded by some observations upon the regions over which the fall of meteorites would appear to have been most frequent. On examining the well authenticated falls of the last half century, it appears that there exist two meteoric regions or zones,—one for the new world, 11° of latitude in width, and mostly lying between the parallels of 33 and 44° of north latitude, whose length is about 25° of longitude, the region having a somewhat N. E. and S. W. direction, and conforming in some measure with the trend of the Atlantic coast; it appearing that 92·8 p. c. of all the meteoric falls for the last half century on the American continent have been deposited within that space, and with a manifest concentration over that part of it lying contiguous to the sea: while the other meteor zone upon the eastern continent, though having the same breadth and pursuing a similar northeasterly track, has more than double the length of the American region, and is very remarkably translated fully 10° of latitude northward of its fellow on the opposite side of the Atlantic. Within this zone, 90·9 p. c. of the falls for the last fifty years reported for the old world, have taken place; attended also with an obvious concentration of them over that half of the region toward the Atlantic.

In respect to meteoric iron (whose time of falling is unknown), the old world has presented us with 14 localities; of these, 11 are situated within the meteoric zone, and mostly between 46 and 52° of north latitude. The new world has already 32, whereof 23 are comprised within its meteoric region, the most of which are found near the parallel of 36°. Europe has for the last fifty years more than four times as many

meteoric falls as America; and less than half the number of deposits of iron, whose time of fall is unknown. This latter circumstance is a fresh proof of the greater geological antiquity of the new world.

2. *On the increase of the Nail and the Hair in Man;* by M. Bertholdt, (L'Institut, No. 846, 93.)—The growth of the nails in children is more rapid than in adults, and slowest in the aged. It goes on more promptly in summer than in winter, so that the same nail which is renewed in 132 days in winter, requires only 116 days in summer—a fact depending on the vis vitalis, which seems to be proportional to it. The increase for the nails of the right hand is quicker than for the left; moreover it differs for the different fingers, and in an order corresponding with the length of the finger, consequently most rapidly for the middle finger, with nearly equal rapidity for the two either side of this, slower for the little finger, and slowest for the thumb. For the middle finger of the right hand the nail grew 12 millimeters in 108 days; for the small finger of the left, 9 millimeters in 152 days: the growth of all the nails of the left hand required 88 days more than for those of the right, and also there were produced in this time 3 millimeters less than on the right hand.

The growth of the hair is well known to be much accelerated by frequent cutting. It forms more rapidly in the day than at night and in the hot seasons than in the cold. But it is difficult to determine the precise rates.

It results from the tables accompanying the memoir of M. Bertholdt, that the growth of the hair and nails as well as that of the epidermis pertains to the secretions and not to the organic structure proper. For (1) the quantity of each formed corresponds very nearly with that of the peripheric secretions, especially with transpiration, it increasing in summer, whilst on the contrary, the growth and nutrition of the body are most rapid in winter, so that the weight of man, as was observed by Sanctorius, Liening, and Reil, is greatest in winter; (2) the growth of the hair least during the night accords with the diminution of all the secretions, as that of transpiration, the formation of carbonic acid, the urinary, lacteal and biliary secretions.

3. *On the Extinction of Light in the Atmosphere;* by W. S. Jacob, Esq., H.E.I.C., Astronomer, Madras. Communicated by Prof. Piazzi Smyth, (Proceedings of Roy. Soc. Edin., vol. ii, No. 36; Jameson's Jour., xlviii, 357.)—In a letter, dated Madras, November, 1849, Captain Jacob says, "I have been much interested in reading, lately, Professor Forbes's paper in the Philosophical Transactions, 1842, Part 2, on the Extinction of Light and Heat in the Atmosphere." His results agree very closely with those of my experience on the Trigonometrical Survey of India, which, though not founded on any precise measures, being still the conclusions of some years' experience, are perhaps worth noticing.

On commencing work with heliotropes in 1837, I soon found that for long distances it was necessary to enlarge the apertures *more* than in the simple ratio of the distances (though such was Colonel Everest's practice); and before the end of the first season, I had formed a scale of apertures for corresponding distances, which afterwards needed very little alteration, but when finally corrected by subsequent years' observation, stood as follows:—

Aperture. Inches.	Maximum Distance. Miles.	Maximum Distance without Absorption.
0·5	15	15
1·0	23	30
2·0	33	60
4·0	45	120
8·0	60	240

Our heliotropes were circular glass mirrors, 8 inches in diameter; and for the smaller apertures, diaphragms were used between the heliotropes and the observer. At the distances stated the light was just visible to the naked eye in clear weather, and when seen over a *valley*: if the ray *grazed* near the surface, the light was much reduced. On one occasion I employed a heliotrope at $6\frac{1}{4}$ miles, and used an aperture of $\frac{1}{6}$ of an inch, and found it rather brighter than usual, so that probably $6\frac{1}{2}$ or 7 miles would be the normal distance for that size.

This agrees well enough with the rest of the scale, but there is no need to employ a conjectural quantity; and if the rate of absorption corresponding to the above be computed, so close an agreement will be found, as may entitle the numbers to be looked on as something better than mere estimates,—as the results, indeed, of a species of observations.

The mean of the whole shows a loss of ·0610 in passing through one mile of atmosphere; with the barometer at 27·0 inches (that being about the average height of my stations), but reduced to 30·0 inches, the quantity will be ·0671.

Hence the loss of light in passing from the zenith through a homogeneous atmosphere of 5·2 miles will be ·303, or only about one per cent. less than Professor Forbes's result. And as my air was considerably drier than his (the mean humidity being not much above ·30 instead of ·56), this will probably account for the difference; and, at any rate, the agreement is much closer than could have been expected.

I once mentioned this matter to Captain Waugh, the present Surveyor-General of India, then my fellow-assistant; but he not only had not noticed the thing, but did not even apprehend my meaning. He assented to my remark on the *loss* of light in passing through the atmosphere, but asserted that the aperture should vary as the distance, thus allowing for *no* loss: 0·1 inch per mile answered, he said, for all distances that he had tried. So it might answer for the distances most usually occurring on the Survey. For 4 inches would be proper for 40 miles, and 2 inches not much too bright at 20, and it is not often that these limits would be passed. Yet it is hardly possible to conceive that he should not have noticed the different intensity of the lights; had not his opportunities been perhaps rather unfavorable, as his work lay chiefly in plains, where, as mentioned above, the light of a grazing ray is very much reduced, and the atmospheric effect would therefore be mixed up with disturbing local causes.

I myself was much astonished at first discovering that the air had so great absorbent powers, and many ideas are suggested by the fact. We see at once how easily many of the planets may be rendered habitable to beings like ourselves. Mars, *e. g.*, may enjoy a temperature little inferior to our own, by having a *less* absorbent envelop; and Venus may be kept as cool as we are, by having one *more* so.

4. *Climate of Australia;* by JOHN GOULD, Esq., F.R.S., F.G.S., &c., (Vide Gould's Birds of Australia; Jameson's Jour., xlviii, 358.)—In a country of so vast extent as Australia, spreading over so many degrees of latitude, we might naturally expect to find much diversity in the climate, and such is really the case. Van Diemen's Land, from its isolated and more southern position, is cooler, and characterized by greater humidity than Australia; its vegetation is therefore abundant, and its forests dense and difficult of access. The climate of the continent, on the other hand, between the 25th and 35th degrees of latitude, is much drier, and has a temperature which is probably higher than that of any other part of the world, the thermometer frequently rising to 110°, 120°, and even 130° in the shade; and this high temperature is not unfrequently increased by the hot winds which sweep over the country from the northward, and which indicate most strongly the parched and sterile nature of the interior. Unlike other hot countries, this great heat and dryness is unaccompanied by night-dews, and the falls of rain being uncertain and irregular, droughts of many months' duration sometimes occur, during which the rivers and lagoons are dried up, the land becomes a parched waste, vegetation is burnt up, and famine spreads destruction on every side. It is easier for the imagination to conceive than the pen to depict, the horrors of so dreadful a visitation. The indigenous animals and birds retire to the mountains, or to more distant regions exempt from its influence. Thousands of sheep and oxen perish, bullocks are seen dead by the roadside, or in the dried-up water holes, to which, in the hope of relief, they had dragged themselves, there to fall and die; trees are cut down for the sake of the twigs as fodder; the flocks are driven to the mountains, in the hope that water may there be found, and every effort is made to avert the impending ruin; but, in spite of all that can be done, the loss is extreme. At length a change takes place, rain falls abundantly, and the plains, on which, but lately, not a blade of herbage was to be seen, and over which the stillness of desolation reigned, become free with luxuriant vegetation. *Orchideæ*, and thousands of flowers of the loveliest hues are profusely spread around, as if nature rejoiced in her renovation, and the grain springing up vigorously, gives promise of an abundant harvest. This change from sterility to abundance, in the vegetable world, is accompanied by a correspondent increase of animal life; the waters become stocked with fish, and the marshy districts with frogs and other reptiles, hosts of caterpillars and other insects make their appearance, and, spreading over the surface of the country, commence the work of devastation, which, however, is speedily checked by the birds of various kinds that follow in their train. Attracted by the abundance of food, hawks, of three or four species, in flocks of hundreds, depart from their usual solitary habits, become gregarious and busy at the feast, and thousands of Ibises (*Ibis spinicollis*) and other species of the feathered race, revel in the profusion of a welcome banquet. It must not, however, be imagined that this change is effected without its attendant horrors; the heavy rains often filling the river beds so suddenly that the onward-pouring flood carries with it every thing that may impede its course, and woe to the unhappy settler whose house or grounds may lie within the influence of the overwhelming floods!

So little has as yet been ascertained respecting the climatology of Western, North-Western, and Northern Australia, that it is not known whether they also are subject to these tremendous visitations; but as we have reason to believe that the intertropical parts of the country are favored with a more constant supply of rain, as well as a lower degree of temperature, it is probable that they do not there occur.

5. *On the Resuscitation of Frozen Fish;* by Prof. O. P. Hubbard, (communicated for this Journal.)—For a number of years, during my residence in New Hampshire, I have received from numerous sources, the statement that fish taken in the cold of winter from our ponds and thrown out upon the ice and freezing quite hard, have been restored to their usual activity when thrown again into cold water.

That they would ever have moved again if left alone is incredible; and how far and for what time a fish may be frozen and yet be restored, is not shown by experiment. I have good reasons from the character of my informers, for believing that the facts are as stated, though when repeated they are hardly credible to others; and I am much gratified in obtaining for publication, the following authentic account of a satisfactory instance.

Persons who have had similar experience are requested to communicate the facts in detail to the writer.

"Sometime in the winter of 1838 or 1839—living near a stream abounding with fish, which emptied into a pond near by, I was in the habit, daily, of catching them, (as they passed down stream,) by means of an eel-pot. This was so constructed as to receive and retain them without injury, if taken out soon, and on one occasion, the pot having remained longer than usual, so many were caught as nearly to fill the pot, and numbers perished from pressure or want of air.

It was the custom to examine the pot in the morning. On one occasion, a severe cold morning, in January I think, I took up the pot and found a considerable number were taken. These I emptied upon the snow, which was deep and so crusted with ice as nearly or quite to bear me up.

I then replaced the eel-pot in its proper bed for another draught, which took me about twenty minutes, and then gathered up my fish, exposed on the snow, into a pail or basket, and found them frozen as stiff as icicles.

I carried them home to the shop, where they remained frozen, according to my recollection, for the space of an hour and a half longer, and so stiff and inflexible that they could not be bent without cracking, as did some of their tails and fins in pulling them apart when they were congealed together. I then put them into a tub of water drawn from the well, to thaw them for dressing, and I think added a small quantity of warm water that stood upon the stove, but am not certain whether it was before or after scaling them.

After some little time, how long I cannot now say, I examined them to see if they were thawed sufficiently for dressing, and to my surprise, I found some of them as lively as when sporting in their native brooks. I called on others to view them, who had seen them while they were frozen. To them also it appeared almost incredible, but we were constrained to believe our own eyes and senses.

I think those fish were *perch* that came to life after (I cannot say death, but) freezing.

In the spring, I remark, we set the eel-pot with its mouth down stream, as then the fish are running from the pond up stream.

Yours, respectfully, PARACLETE SKINNER."

Woodstock, Conn., Dec., 1849.

6. *Geology in the State of Mississippi.*—We learn from our correspondent, Mr. M. Morris, that the Legislature of Mississippi at its recent session, has made a standing appropriation of $5000 per annum, to provide for a geological survey of the state, in connection with a geological professorship at the State University.

For years the subject had been ineffectually agitated, but the organization of a "State Geological Society" in March last—the publication of numerous popular articles on geology,—and the collection and exhibition to the Legislature of a rich cabinet of Mississippi specimens, accompanied by discussion on geology in the chamber of the House of Representatives, (out of business hours,) are among the principal causes which have brought about a result so fruitful of promise, and which we hope may be fully realized.

7. *On the Purification of Coal-Gas;* by R. LAMMING, (Athenæum, No. 1176, p. 508.)—The author's process (which has been hitherto successfully put in action at Paris,—at the Chartered Company's Westminster Works, on a small scale,—and at the Imperial Company's Haggerstone Works, on a larger scale) consists of two parts. First, the removal of the impurities from the gas; secondly, the revivification of the used material, which is again made capable of service. The purifying material is a saturated solution of muriate of iron decomposed by lime into muriate of lime and hydrated protoxyd of iron, mixed with breeze [coke in small fragments]; during the mixing, the iron becoming peroxyd (carbonate) from the oxygen of the air. On passing the gas through this material in the ordinary purifiers, the following changes take place:—The sulphuretted hydrogen combines with the peroxyd, forming water and sesqui-sulphuret of iron; the ammonia and carbonic acid join to form proto-carbonate of ammonia, which again acts on the muriate of lime to form muriate of ammonia and carbonate of lime. This proceeds until none of the peroxyd of iron and muriate of lime are unchanged. The purifier is then thrown out of connection, and a current of air passed through the used material, by which it is revivified in the manner following:—The sesqui-sulphuret of iron becomes, from the oxygen of the air, sesqui-sulphate of iron; after which this salt and the carbonate of lime decompose each other, becoming sulphate of lime and carbonate of protoxyd of iron; the latter speedily changing into hydrated peroxyd of iron, while the carbonic acid is liberated and escapes. Thus the material is brought back to its original condition, excepting that for muriate of lime has been substituted precipitated sulphate of lime, having the same affinity for carbonate of ammonia as the muriate has. In warm weather this revivification takes place in a very short time; but in winter it requires the aid of artificial heat. The same purifying material is capable of being used nine successive times without any appreciable diminution of its power, and at last becomes inefficient only from the accumulation of ammoniacal

salt, which can be removed by simply washing. The result of this process on the gas is to remove one equivalent of carbonic acid for one and a half of ammonia and one and a half of sulphuretted hydrogen. But as the gas contains more sulphuretted hydrogen than ammonia, and more carbonic acid than sulphuretted hydrogen, it is necessary to submit it a second time to a material like the former, but with an excess of hydrate of lime. Here the sulphuretted hydrogen still left seizes on the oxyd of iron, the carbonic acid being absorbed by the lime.

8. *Analysis of Water from a Hot Spring in the region of the Great Salt Lake;* by C. T. Jackson, (Proc. Bost. Soc. Nat. Hist., 1850, 224.)—This spring issues from a hill of sandstone from two to three thousand feet in height. The water is agreeable, saline, and when fresh contains a little sulphuric acid, and carbonic acid gas. The temperature is 108° F. One pint contains 44 grains of solid matter, as follows:

Carbonate of lime,	1·280
Perox. iron and trace of manganese,	0·208
Lime,	2·907
Chlorine,	18·421
Soda,	15·344
Magnesia,	2·073
Sulphuric acid,	3·748
	43·981
Loss,	·019
	44·000

9. *Wild Animals of Africa*, (Athen., No. 1176, p. 504.)—An exhibition of a novel and attractive character has just been opened at Hyde Park Corner. Mr. Roualeyn Gordon Cumming, a young gentleman of property in the Highlands, and as keen a sportsman as the Highlands has ever produced, has filled the old Chinese Gallery with the trophies of his skill—the produce of five years' shooting in the far interior of Southern Africa, many hundred miles beyond the farthest point hitherto reached by any white man. When we state that Mr. Cumming has killed eighteen lions, twenty-eight specimens of the black rhinoceros, thirty-nine of the white rhinoceros, seventy-six hippopotami, and one hundred and five elephants, our readers will know what his daring is and what his success has been. His lion's skins are the finest we remember to have seen,—worthy coverings for the king of beasts. He has at least one thousand pounds' worth of ivory in the room, and a pair of elephant's tusks measuring nine feet,—the largest known. The whole Gallery looks like a combination of a baronial hall and a furrier's shop. Antlers of the largest size and the most elegant proportions arrest the eye at every turn. The fore-feet of an elephant (exhibited on the dais) afford a noble idea of the enormous size of the herds of elephants which he had the luck to fall in with.

10. *Tin in Plumbaginous Slates.*—Dr. Jackson notices (Proceedings Boston Soc. Nat. Hist., 1850,) the fact, that the plumbaginous slates of Vermont furnish on assay, malleable grains of tin and iron, when fused in a crucible, lined with lampblack. This fact appears to Dr. Jackson to indicate the existence of tin lodes in that region.

11. *On Fossil Rain Drops*, (Proc. Bost. Soc. Nat. Hist., 1850, p. 200.) —Mr. Desor communicated some observations made by Mr. Whitney and himself in reference to the probable origin of the so-called fossil rain drops, which in this country, are found on slabs of new red sandstone, as well as Potsdam sandstone.

He said it had already been noticed by Mr. Teschemacher that these so-called rain drops, when closely examined, are found to differ in several respects from the impressions made by the rain on a beach, where each drop produces an impression surrounded by a rough crest, more or less elevated according to the force of the rain. The fossil impressions on sandstone, on the contrary, are generally flat and smooth. Besides, there is hardly a shower in which the rain drops are not numerous enough to cover the whole or nearly the whole ground, whereas the fossil impressions are generally scattered and so few in number that it seems almost impossible to ascribe them to rain.

Mr. Desor said, that whilst encamped on the border of Lake Superior, they had several opportunities of studying the action of the waves on the beach during a heavy surf, when they are driven beyond their usual range. It was noticed that when the waves retired from the higher part of the beach, where the slope was less steep, there could be seen several kinds of impressions in the act of forming, some large and flat, others small and deep, (like those which on the sea-shore are generally ascribed to worms or shrimps,) and others likewise deep, but surrounded by a sort of annular, smooth rim. These different kinds of impressions are all produced by the same cause, operating in the same way, namely, air bubbles, which are formed in the waves of the surf, when rolling over the beach. If an air bubble becomes buried in the sand, so that in order to escape it has to make its way through the new-formed stratum of sand, it forms a deep and narrow hole. If the air instead of escaping at once, bubbles up several times, then it raises around the hole a small and smooth rim, which may be compared to a miniature crater of a volcano. If, on the contrary, the air bubble remains at the surface and bursts, then it causes a flat and rather large impression. According to Messrs. Whitney and Desor, these different forms of impression arising from air bubbles, are sufficient to account for most impressions which have hitherto been considered as the effect of rain. Such impressions of air bubbles are most perfect where the slope of the beach is very gentle. Where the slope is more or less steep, the sand becomes too much hardened under the pressure of the waves to allow these delicate impressions to be produced.

A sketch was exhibited, showing these different forms of impressions, and their striking contrast with impressions of rain drops from the same beach, mouth of Carp River, Lake Superior.

Mr. Teschemacher said, that he had seen fossil rain drops, so-called, with an elevated ridge crossing them; an appearance easily explained by Mr. Desor's hypothesis, but incompatible with the supposition that they were caused by rain.

Prof. Agassiz said, that on the mud flats at Cambridge, he had noticed impressions made in the way described by Mr. Desor at Lake Superior.

12. *Expedition in Search of Sir John Franklin.*—The American Expedition equipped at the expense of Mr. H. Grinnell, a munificent merchant of New York, consists of two vessels, which are classed as brigantines in our naval service—the "Advance" of 144 tons, and the "Rescue," of 91 tons. On Mr. Grinnell's petition to Congress, the vessels have been placed under the command of the U. S. Navy, and officers and men detailed to this hazardous service. The whole is under the command of Lt. Edwin De Haven, an officer of great zeal, courage and experience. The Advance has a crew of fifteen men, and the Rescue thirteen. Both vessels were fitted with every artifice and appliance to ensure safety against extreme cold and the crushing effects of the ice packs. Passed Midshipman Griffin commands on board the Rescue. The expedition sailed on the 22nd of May, for Baffin's Bay, thence to touch at Disco Island, a Danish whaling station in latitude 70° on the coast of Greenland, where they will water before steering for Lancaster Sound and Barrows Straits, with the intention of penetrating an open sea supposed to exist between Parry's Islands and the pole. Should the ice admit they will go up the Wellington Channel, and if not they will cruise westward to Cape Walker and around Melville Island. Should all progress westward in this direction be obstructed, they will return to Baffin's Bay and attempt to enter Jones Sound or Smith's Sound, in lat. 79° N., at the extreme northern point of Baffin's Bay. Should the supposed western sea be open to the vessels, they may at their discretion go through Behrings Straits into the Pacific and communicate with the American Squadron in those seas, who have orders to furnish every assistance in their power. Lt. De Haven has discretionary power to modify or abandon this general plan, should the success of the Expedition demand it. This humane and truly liberal enterprise is solely at the individual cost of Mr. Grinnell, who has received very gratifying testimony from Lady Franklin, of her approbation of the effort. The vessels carry letters from Lady F. to Sir John Franklin, and the Admiralty have furnished Mr. Grinnell with copies of the Esquimaux vocabulary compiled by Capt. Washington, R. A.

It is also understood that not less than three Expeditions have sailed from Great Britain for the same purpose, and all fitted in the most complete manner. One of these is commanded by the renowned Sir James C. Ross.

13. *Discovery of a Comet.*—On the 1st of May, 1850, at 10^h m. t., Dr. Petersen, at the Altona Observatory, discovered a faint telescopic comet, but the weather that evening was too unfavorable for observation. Its estimated place was R. A. $19^h\,25^m$, and North Decl. 71° 10′. From two days' observation, its daily proper motion was found to be, in R. A. $-1^m\,3^s{\cdot}3$, and in declination $+9'\,44''$.

The announcement of the discovery of a comet in Nov., 1849, (see vol. ix, p. 442,) needs confirmation.

14. *American Association for the Advancement of Science.*—The third annual meeting of this Association will assemble in New Haven on the 19th of August next, being the *third Monday* of the month, at 10 o'clock.

The easy access which may be had to New Haven from all quarters by railway, renders it highly probable that the ensuing meeting will be

one of the largest and probably *the* largest ever yet assembled. Dr. Bache of Washington is the President of the year. For further particulars we refer to the circular of the Local Committee and to the advertisement to be found among our advertising pages.

15. The next meeting of the British Association for the Advancement of Science, will be held at Edinburgh in August next.

16. Mr. Edward J. Chapman has been appointed to the Professorship of Mineralogy recently instituted in University College, London.

OBITUARY.

17. Lieut. HENRY ELD, Jr., U.S.N.—Lieutenant Eld, son of Mr. Henry Eld, of New Haven, Ct., died in March last, of yellow fever on board the Ohio, soon after leaving Rio Janeiro. He was an officer of high character both as regards seamanship and general scientific attainments; and his personal qualities—his energy, decision, promptness and natural dignity, connected with the highest generosity and kindness of heart, had secured him universal esteem among his associates, and the unbounded confidence of the naval department; all who knew him, recognized him as one calculated to confer honor upon the highest stations in his profession to which he might have been called by his country. Lieutenant Eld was one of the officers of the Exploring Expedition under Capt. Wilkes, which navigated the Pacific and Southern Seas, and circumnavigated the globe during the years 1838–1842. During a large part of the cruise he was directly associated with Capt. Wilkes in the philosophical investigations, (magnetic, &c.,) carried on at different stations; and in all these duties he was known for his skill and fidelity. He was of the party under the Commander's direction that spent three weeks on the summit of Mt. Loa (14000 feet in height) for the purpose of making pendulum and other observations. (See Narrative Expl. Exp., vol. iv, chapter 4.) An exploring party through the Chikelis country in Oregon was under his command, (Narrative, vol. v, p. 123,) and he was also associated with Lieutenant Emmons and others in a tour of fifty days over the wild country between the Columbia River and San Francisco, (Narr., vol. v, chap. 6). Aboard the Peacock in the Antarctic cruise of the Expedition, Lieutenant Eld was the first to descry land. He was stationed at the crosstrees along with Lieut. Reynolds (both of them then Passed Midshipmen) on the 16th of January, 1839, when he exclaimed "land!" and Lieut. Reynolds responded almost simultaneously "so it is." After reporting it to Capt. Hudson, these officers fully confirmed the opinion with a glass; and although the announcement was at first received with hesitation by some, it was fully confirmed by subsequent events. The honor which the country claims of having anticipated the French under D'Urville, rests upon this observation. A few hours later the French had made the same discovery.

18. M. GAY-LUSSAC died in Paris on the 10th of May, aged seventy-one. He was one of the greatest of the scientific men of France. "Few men," says the *Presse*, "have led a life so useful and marked by so many labors. There is no branch of the physical and chemical sciences which is not indebted to him for some important discovery.

Alone, or in conjunction with other eminent men, particularly with Thénard and von Humboldt, he carried his spirit of investigation into them all. At a very early age he was elected a member of the Academy of Sciences. In 1810, says M. Pouillet,—speaking in the name of that Academy,—when the University opened, at length, its public courses of high teaching, it sought to associate in that object the most eminent scientific men of France,—and M. Gay-Lussac, though very young, recommended himself to it by the double title of chemist and natural philosopher. M. Gay-Lussac was already famous by his discovery of the fundamental laws of the expansion of gas and vapors,—by a balloon ascent, the most important and almost the only one of which the history of science has any record to keep,—and for many works on chemistry which tended to lay the basis on which that science was soon afterwards to be established."—M. Gay-Lussac was a Peer of France.

19. M. P. Souyet, an eminent chemist, died lately at Brussels at the early age of thirty-two. M. Souyet was Professor of Chemistry at the *Musée de l'Industrie* and at the Royal Veterinary School at Brussels. His funeral, on the 6th of May, was attended by the most eminent scientific men in Brussels; and M. Quetelet delivered an address, in which he briefly enumerated the important discoveries and chemical investigations that have rendered the name of M. Souyet so well known. M. Souyet had written several valuable chemical works.

20. M. Ducrotay de Blainville died in May, in his seventy-third year. He was found dead in a railway carriage upon the Rouen road on his way to England. He was the successor of Cuvier in the chair of Comparative Anatomy at the Museum of Natural History in Paris. He maintained his activity in science to the very last.

21. M. Kunth, a distinguished Botanist, Professor of the University of Berlin, died at Berlin, March 22, 1850.

22. Dr. Prout, the author of the Bridgewater treatise on digestion, &c., died in London about the middle of April.

V. Bibliography.

1. *A System of Mineralogy, comprising the most recent discoveries; including full descriptions of Species and their Localities, Chemical Analyses and Formulas, Tables for the Determination of Minerals, and a Treatise on Mathematical Crystallography and the Drawing of Figures of Crystals;* 712 pp. 8vo, illustrated by numerous wood cuts and four copper plates; by James D. Dana, A.M., etc. Third edition, rewritten, rearranged, and enlarged. New York and London: published by George P. Putnam, 1850.—In noticing this work we cite the Author's Preface, in which the changes the Treatise has undergone are mentioned, and the various contributions received from different sources are acknowledged.

"This Treatise, in the present edition, has undergone so various and extensive alterations, that few of its original features will be recognized. The science of Mineralogy has made rapid progress in the six past years; chemistry has opened to us a better knowledge of the nature and relations of compounds; and philosophy has thrown new light

on the principles of classification. To change is always seeming fickleness. But not to change with the advance of science, is worse; it is persistence in error: and, therefore, notwithstanding the former adoption of what has been called the 'Natural History System,' and the pledge to its support given by the author, in supplying it with a Latin Nomenclature, the whole system, its classes, orders, genera, and Latin names, have been rejected; and even the trace of it, which the synonymy might perhaps rightly bear, has been discarded. The system has subserved its purpose in giving precision to the science, and displaying many of the natural groupings which chemistry was slow to recognize. But there are errors in its very foundation which make it false to nature in its most essential points: and in view of the character of these errors, we are willing it should be considered a relic of the past.*

Yet science is far from being ready with an acceptable substitute. Most *chemical* systems have been more artificial than the 'Natural' system; and doubts now hang over some of the principles of chemistry that are widest in their influence on classification. In view of the difficulties on either side, it was a point long questioned, whether to venture upon a classification that might be deemed most accordant with truth among the many doubts that surround the subject; or to adopt one less strict to science, that might subserve the convenience of the student for easy reference, and for the study of Mineralogy in its economical bearings, while at the same time it should exhibit many natural relations, and inculcate no false affiliations or distinctions of species. The latter alternative has been adopted:—the classification is offered simply as a convenient arrangement, and not as an exhibition of the true affini-

* In the course of the volume the following paragraphs occur exhibiting the relation of Mineralogy to the other Natural Sciences, and the author's reasons for rejecting the system followed in his former editions.

"The whole range of inorganic substances, whether made by art or existing in the earth, constitute the Inorganic Kingdom. Minerals, as the term is used, are those species of this vast kingdom, that occur ready-made in the earth's crust. They exist by no different forces from the compound that proceeds from the laboratory; for it matters not whether sulphuric acid and lime come together in the workshop of art or nature; whether the hand of man bring the materials into juxtaposition, a running brook, an exhaling spring, or a volcanic fumarole: the result in both cases is gypsum, identical in chemical, physical, and crystallographic characters. The Science of Mineralogy hence, treats of only a small part of the third kingdom of nature. It includes here and there a species from the system—that is, those species that happen to have been formed by out-door processes. The limits of the department are not based on any grand points of difference between these and other inorganic compounds; they are assumed, in order to present together a collection of facts, which the student conveniently considers in one connection—facts relating to the natural productions of our globe.—p. 18.

In the classification of minerals it must be fully understood that we are dealing with but a small part of the third department of nature—the Inorganic Kingdom. The term Mineral Kingdom, so often used, is fundamentally erroneous, although all natural products not organic may be embraced under it. The distinction between *natural* and *artificial* inorganic products is convenient for the student, but is contrary to strict science; for nothing authorizes the wide separation usually admitted but the necessities of the school-room, or the fact that mineral information is the A B C of another science, and the basis of certain arts. Any classification therefore that can claim to be perfect, must take into consideration the whole range of inorganic compounds; and each species should have its place fixed on the broadest principles of the science of inorganic nature. A thorough knowledge of chemistry is required

ties of species in the highest sense of the term. Among the silicates, however, it will be perceived that the groupings in the main are natural groupings; and throughout the work, special care has been taken to inculcate, as far as possible, the true relations of species, both by remarks, and by an exhibition of them in tables.

The system of classification which has been set aside for the arrangement adopted, is presented in a tabular form in the latter part of the volume. It is recommended as the preferable plan for arranging a cabinet, since it groups together species that are fundamentally alike —that is, alike in chemical and crystallographic characters—and prominently exhibits the various cases of isomorphism and polymorphism among minerals.

Special effort has been used to give completeness to the chemical descriptions of species, while at the same time, crystallography has not been neglected. In the latter department, a Mathematical chapter has been added, after Naumann's system—the system generally adopted in Germany, and recommended by its simplicity; and a second on the Drawing of Figures of Crystals. On the other side, the number of chemical analyses introduced has been increased fourfold, so that the student will have before him, a full registry, in most cases, of all mineral analyses hitherto made that are worthy of confidence. Chemical formulas have been given, and also the various opinions of different authors, where the constitution of a species is still in doubt. The most recent investigations in foreign Works and Journals, as far as they have reached this country, have been examined, and the Treatise is therefore posted up to the hour of its leaving the press. About one hund-

---

to appreciate such an arrangement, and the fullest development of the science to give it perfection.

This view lowers mineralogy from its usual rank along side of botany and zoology. It exhibits, however, the true character and standing of the science, and enables us to appreciate its real objects and scope, and the basis upon which a classification should rest.—p. 170.

A systematic nomenclature like that for botany and zoology, is out of place in this science, for reasons already stated, except it be based upon relations among the whole range of inorganic products. The author here departs widely from principles deemed important in former editions of this treatise. The arrangement of Mohs, followed in the main heretofore, has not for some time been esteemed by him satisfactory, and it has been more and more obvious, with every passing year, that it could not stand the test of the developments of science. Even on its assumed ground of being a *natural* system, it is in many parts singularly artificial; and now that prejudices of early instruction have lessened, it seems little better in some of its groupings that an ancient classification of plants which arranged the hard wood species in one group, the herbaceous in another, or collected together flowers of a color. For it is on no better ground that the diamond is placed along side of topaz and sapphire; spathic iron near heavy spar, (instead of near calcite); graphite near psilomelane; allophane with green malachite; mica in the same order with cronstedtite, spodumene with prehnite; iolite with quartz and chrysolite: and so on. Some of these incongruities, the author in adopting the arrangement, had thrown out; but others remained, and were inseparable from the system. Yet in justice to this Mineralogist of merited celebrity, it should be said, that very many natural groupings were embraced in his classification—far more, indeed, than in many of the recent *chemical* systems; for the latter refusing almost all reference to physical characters, and considering only the elements present, instead of the mutual relations of the constituent elements, have broken up species into fragments and strewed them about into most heterogeneous assemblages."—p. 171.

red new species have been added to the science since the appearance of the preceding edition.

In the department of American Mineralogy, no pains have been spared to render the Work as complete as the nature of the case admitted. The Author would here gratefully acknowledge the valuable assistance he has received from various sources. He would especially mention his indebtedness to Dr. C. T. Jackson, for information upon the minerals of the Michigan Copper region, with Analyses of Telluric Bismuth of Virginia, and Chrysocolla, Apophyllite, and Analcime of Michigan, besides a description of Vermiculite, and an Analysis of this species in his laboratory by R. Crossley; also to Mr. Crossley, for an Analysis of Algerite and Schorlomite;—to J. E. Teschemacher of Boston, for observations on many species, including the Crystallized Black Copper ore and a Vanadate from the Lake Superior region;—to A. A. Hayes of Boston, for the blowpipe characters of Pyrrhite, and facts relating to Red Zinc Ore, and some other minerals;—to M. Adolph Schlieper, now of Lowell, Mass., for an Analysis of a Volcanic Labradorite, and the Cummington Manganese Spar;—to J. C. Booth of Philadelphia, for Analyses carried on in his laboratory of Emerylite, Euphyllite, Marmolite, an Iridescent Pyrites, a supposed Allanite, and other investigations, performed by T. H. Garrett, J. D. Darrack, and Ch. Hartshorne;—to Wm. S. Vaux and T. F. Seal of Philadelphia, and L. White Williams of Westchester, Pa., for much important information on the localities and minerals of Pennsylvania and Delaware;—to H. Wurtz of New York for Analyses of Brucite, and Nemalite, besides a new species he has named Melanolite;—to Hon. T. L. Clingman of North Carolina, for a catalogue of the North Carolina minerals;—to D. D. Owen and J. G. Norwood for an account of the minerals of Wisconsin, and other parts of the West;—to B. Silliman, Jr., for Analyses of Emerylite, and other species, and for aid in the optical examination of the American Micas, besides help of various kinds in the progress of the Work;—to H. Erni, assistant chemist in the Yale Laboratory, for Analyses of Danburite, Euphyllite, and a Feldspar;—to W. J. Craw of the same laboratory, for Analyses of Emerylite, W. H. Brewer, for Analyses of Hudsonite, and a Mica, (Margarodite), G. J. Brush, for Analyses of Williamsite, Deweylite and an Opal, J. B. Bunce, for an Analysis of Wollastonite;—to T. S. Hunt, for a catalogue of the mineral localities of Canada, and a description of the new species, Nickel Vitriol;—to Dr. F. B. Hough, for a catalogue of the localities of Northern New York, and a notice of the Capillary Pyrites of Antwerp;—to O P. Hubbard, for facts relating to the minerals of New Hampshire.

With so many Collaborators, the Work must bear some evidence of progress in American Mineralogy. The persons here mentioned are independent of those whose publications have appeared during the past six years—among whom we cannot properly leave unnoticed the names of C. U. Shepard, J. D. Whitney, Wolcott Gibbs, B. Silliman, Jr., T. S. Hunt, J. E. Teschemacher, F. Alger, L. C. Beck,—and W. Fisher, J. S. Kendall, and G. J. Dickinson of Prof. Booth's Laboratory, whose labors among American Minerals will be found reported under the species Schorlomite, Brookite, Ozarkite, Zircon, Gibbsite, Allophane, Boltonite,

Unionite, Albite, Kyanite, Nuttalite, Serpentine, Algerite, Sodalite, Davyne, Brucite, Tetradymite, Garnet, Vivianite, Chondrodite, Pectolite, Wollastonite, Coracite or Pitchblende, Azorite, Chromic Iron, Black Copper, Pyroxene, Hornblende, Chladnite, and Shepardite.* If we cannot number many new species, we may claim that our knowledge in numerous cases has been rendered more precise. Some species of uncertain titles have been restored to credit, while others have been stripped of their seeming claims.

Among foreign laborers on American species, we should make honorable mention of M. Hermann, who has analyzed the Manganese spar of Stirling and Cummington, Gibbsite, Jeffersonite, Columbite, Pennite, and the so-called Troostite;—also of Prof. H. Rose, whose labors on Columbite are well known;—also of Rammelsberg, Delesse, Marignac, Damour, and Kerndt, to whom the Science is indebted for analyses or descriptions of American Bismutite, Brookite (Arkansite), Schorlomite, Washingtonite, Chrysoberyl, and Wolfram.

In the preparation of this edition, and especially the elaboration of its Chemical part, the Author has availed himself freely of the Chemical Mineralogy—'Handwörterbuch des Chemischen Theils der Mineralogie'—of Rammelsberg, and its biennial Supplements, in which all that is published respecting the composition of minerals is posted up with a fullness, discrimination, and erudition that leaves little for another hand. The tables of Analyses are, to a great extent, only another arrangement of the very valuable Work of this distinguished Chemist and Mineralogist. The various Foreign Scientific Periodicals and Transactions have also been consulted, both of Britain, France, Germany, and Russia, and every care has been taken to insure correctness and accuracy. Many facts of very recent date, that were received through new publications, or as private communications from different contributors to the Work, subsequent to the printing of the earlier part of the volume, are contained in an Appendix; and the reader will find it of use to him to add to the descriptions of species in the body of the volume, the number of the page in the Appendix where the mineral is again treated of.

The introduction of a table of atomic weights places it in the power of any, who will take the little trouble needed to understand its use, to calculate the results of analyses and test or compare their formulas. To the young student this will be found a most instructive exercise: and the proficient in the Science will appreciate the benefit of having a table of the kind at hand, arranged for easy reference."

We add further, that the volume contains 80 pages more than the preceding edition. And as about 70 pages of that edition are omitted, including the chapter on Rocks, and that on Mineralogical Bibliography (excepting four pages devoted to a list of the Works and Journals referred to in the course of the treatise);—and moreover since the mode of stating the results of analyses has reduced two-thirds the space the same

* The name of Dr. Boyé should have been included, who published in the Proceedings of the Philosophical Society of Philadelphia, ii, 190, May, 20, 1842, an analysis as follows of the Granular Albite of Westchester, Pa.; silica 67·72, alumina with a trace of iron 20·54, magnesia 0·34, lime 0·78, soda 10·65, potassa 0·16=100·19.

J. D. D.

amount would occupy, while the whole number of analyses given is increased fourfold, the quantity of matter added to this edition and not contained in the former is over 225 pages. The various additions have been made without increasing the size of the volume, a result partly secured by the use of good and firm instead of thick paper.

2. *The Unity of the Human Races proved to be the Doctrine of Scripture, Reason and Science, with a Review of the present position and theory of Prof. Agassiz;* by the Rev. Thos. Smyth, D.D. New York: G. P. Putnam. pp. 404, 12mo.—This volume is understood to have grown immediately out of the discussion on the unity of the human races at the late meeting of the American Association for the Advancement of Science held at Charleston. On that occasion, Prof. Agassiz appeared as the advocate of original plurality in the distributive centers of our race, but distinctly avowed his belief in their *spiritual* unity.

Dr. Smyth advocated the scriptural doctrine as it is usually understood and maintained, and the present volume is an exposition of this view of the subject.

On this question so interesting alike as a zoological, ethnological and moral enquiry, every enquiring mind will form its own conclusions. It is a perfectly fair subject of research, and nothing but the most exclusive and proscriptive bigotry can object to its free discussion. It is also a question on which many earnest minds seek light. It is intimately connected with the whole history of our race and cannot be pursued without constantly acquiring new facts relative to the arts, literature and commerce of the ancient nations. The scripture doctrine as generally received on this subject is most explicit and full,—that men sincerely desirous of knowing only the truth have found difficulty and doubt in investigating the subject, is a proof it is less simple than many have supposed. Dr. Smyth's book will be read with lively interest by all who are interested in candid discussion, and we wait with eagerness the arguments which his celebrated antagonist will bring to meet the conclusions of the present work.

3. *Report of Prof.* Alexander D. Bache, *Superintendent of the (U. S.) Coast Survey, showing the progress of that work for the year ending October*, 1849. 31st Congress, 1st Session. Ex. Doc. No. 4. 8vo, pp. 98, with 16 maps and sketches.—This report like its predecessors from the same source, gives ample evidence of the zeal, progress, and the highest scientific attainment in the prosecution of the great task of carrying out and completing the survey of the coasts of the United States. The report contains:—1. A general statement of the progress of the coast survey, and of the publication of its results. 2. A separate summary of the progress during the past year. 3. The work proposed for the next *fiscal year*, with the estimated cost. 4. A more detailed account of the several operations in each section of the survey, under the different officers, with a notice of the results obtained. 5. An account of the office work for the year. An Appendix contains tables of occupation of the parties and results, reports from the assistants on matters of interest to navigation, lists of maps published, and the like. The general progress of the coast survey as summed up in this report, occupies several pages, arranged under the sections into which the work is divided. The great increase of our coast line con-

sequent on the acquisition of California, &c., has much increased the labor and time required in the ultimate completion of the entire work. Dr. Bache remarks that the operations of the survey are now generally understood; but it is not so generally known that the scientific parts of the work which give it its great value—its essential value—are not the expensive parts, but that those most eminently practical are those that are most costly.

Dr. Bache states that the whole coast of the United States is very remarkably well adapted for the application of the geodetic method of survey. The difficult parts of the coast are reduced to so small a space that it is scarcely worth considering, and it is remarkable how the constant tendency is to contract this to still smaller dimensions, and how a close examination develops unexpected facilities, diminishing the resources required in applying a method which is as flexible as it is exact.

The magnetic telegraph has given new precision to this kind of survey just in the point in which it was least strong, and has rendered the measurement of an arc of a parallel an operation of the same kind with the measurement of an arc of the meridian.

A sketch of the operations of the coast survey in this new means of physical research will be found in the Appendix to the present number of this Journal. For further and important details we refer to the report itself.

4. *An Elementary Course of Geology, Mineralogy and Physical Geography;* by DAVID T. ANSTED, M.A., F.R.S., &c. London: J. Van Voorst, Paternoster Row. 1850. pp. 584, 12mo.—Prof. Ansted established his position as a successful scientific author in his scholar-like "Geology, Introductory, Descriptive and Practical," 2 vols., 8vo, published in 1844. The "Ancient World" of the same author, has also contributed largely to his reputation, and both those works have prepared the way for the present manual. It is what its title indicates, an *Elementary* treatise on the several subjects embraced in its range.

The order pursued is first, PHYSICAL GEOGRAPHY, in which are discussed the properties, conditions and forces of matter, the form, density and temperature of the earth, the distribution of land and water, rivers, lakes and mountains, plains, savannahs and deserts: the atmosphere and ocean with all the physical phenomena appropriate to them—changes in the earth's surface by the operation of temperature, winds and currents, or by organic agency—coral reefs, deltas, and distribution of marine animals. This department is closed by a chapter on the reaction of the interior of the earth on its external surface, under which head of course are grouped all the physical facts due to internal heat, geysers, mineral and hot springs, earthquakes and volcanoes with their geographical distribution.

The second chapter is devoted to MINERALOGY which is considered chiefly as the alphabet of geology and the exposition of products from the great laboratory of nature. The author has contrived to condense a great amount of information into this chapter in a tabular form, including numerous analyses, and he has added also brief descriptions of the most important minerals. At the close of this chapter a full index is appended containing about 1150 names of minerals, with references to the page where mentioned.

The third part of this work is devoted to DESCRIPTIVE GEOLOGY in which the nature, mode of aggregation and metamorphoses of rocks are dwelt on, their structure and mechanical displacement described, their classification through the distribution of organic remains is explained, and the value of fossils in determining relative age. After this follow chapters on the several great formations with their characteristic fossils.

Part fourth is occupied by PRACTICAL GEOLOGY exhibiting the application of geology to agriculture, to engineering, and to architecture. The final chapter is devoted rather fully to mining operations, and their reference to geological structure.

Not the least interesting portion of the volume to those engaged in scientific instruction, is the Appendix, containing in detail the schedules for examination of students in geology and mineralogy at Kings College in London, from June, 1840, to September, 1849. A judicious glossary of terms employed closes this useful work.

It is so seldom that we find a work of any kind, and particularly a scientific work, which has either an index or table of contents of any value, that when one like the present does present itself, so fully equiped for usefulness in this respect, we cannot pass it without a word of commendation and approval. Next to having the inherent qualities of excellence in a book do we value these indispensable aids in reference, without which the labors of an author deserve the oblivion which we are persuaded they often meet, from the neglect of a duty which is none the less important because it is irksome and repulsive.

We look for an early American edition of Prof. Ansted's work.

5. *The Natural History of the British Entomostraca;* by W. BAIRD, M.D., F.L.S., etc. London, 1850. 364 pp., 8vo, with 36 lithographic plates, partly colored. Published by the Ray Society.—Dr. Baird has very thoroughly investigated the Entomostraca of Britain, and able articles from him have from time to time appeared during some past years in different English publications.* The present volume embodies all his former researches, with many others recently made, and embraces full descriptions with the synonymy of all British species known, and observations on the general characters and habits of these minute Crustacea. The species are illustrated with figures, which in many cases are given with minute details of structure. The publication of works of such merit by the Ray Society commends this association to all interested in the progress of science.

6. *Index Palæontologicus, oder übersicht der bis jetzt bekannten Fossilen Organismen*, unter Mitwirkung der HH. Prof. H. R. GÖPPERT und HERM. VON MEYER, bearbeitet von Dr. H. G. BRONN. Part I, *Nomenclator Palæontologicus*, alphabetically arranged, lxxxiv and 1384 pp. 8vo; Part II, *Enumerator Palæontologicus*, or a systematic grouping of fossils, exhibiting their positions in the rock series, and their relations to the successive geological epochs, 980 pp. 8vo.—This new Palæontological work by Dr. Bronn, and his learned coadjutors,

* The Magazine of Zoology and Botany, i, 35, 310, 514, ii, 132, 400; Annals and Magazine of Natural History, (continuation of the preceding,) i, 245, xi, 81, xvii, 410, and 2nd series, i, 21, 396;—Also Trans. Berwickshire Nat. Club; Dieffenbach's New Zealand.

Göppert and Meyer, exhibits in every part the most laborious research, great skill in arrangement, and a wide comprehension of the bearing and relations of the various facts in the science. Part I, commences with some general remarks on the study of fossils. A Bibliography follows, extending over 36 pages, and half as many more are occupied with an explanation of the abbreviated references. Then begins the *Nomenclator*, which is an alphabetical list of all known genera and species of fossils, covering 1380 pages. The author of the name in each case is mentioned, the page of the work or Journal on which described, the plate and figure if figured, the rock formation to which the species belongs, often the country where it occurs, with occasional synonyms and important observations upon the family or class in zoology to which each genus pertains. The system of condensation is carried so far that, in general, all this information is embraced in a single line, or even less. It is obvious that a work of this kind carefully prepared is exceedingly valuable to such as are interested in the study of fossils. Dr. Bronn states that he was nine years in the preparation of the work, and in that time the number of described species was doubled.

Part II, or the *Enumerator Palæontologicus*, consists of tables exhibiting the geological distribution of species, both as regards the series of rocks (26 divisions in which are referred to, and still others subordinate) and also the continent and part of continent where found. The species are systematically distributed according to the natural orders or families. The relations of the different groups to the different geological epochs is thus exhibited to the eye. The great subject of the dependence of species on the circumstances under which they existed, or their accommodation in organization to these circumstances, is presented in a strong light, both in the tables and subsequent chapters. There are other tables and other subjects discussed with ability, for which we must refer to the work.

We understand that this valuable work may be had in this country of Mr. Garrigue and of Westermann, Brothers, in New York City, of Eggers and Co., Cincinnati, and of F. Schuster, in St Louis.

Prof. Bronn will soon be engaged upon a new edition of his Lethæa Geognostica, which work will be greatly enlarged.

7. *Elements of Scientific Agriculture, or the connection between Science and the Art of Practical Farming*, (Prize Essay of the New York State Agricultural Society,) by Prof. John P. Norton, M.A.: Albany, E. H. Pease & Co., 1850. pp. 208, 12mo.—"This little treatise is an attempt to supply a great and growing want in our country; a want of some elementary work that shall clearly and distinctly explain the great principles that are involved in the application of science to agriculture." —(Preface.)

In the opinion of the Committee of the New York Agricultural Society, of the authorities of the State and of the leading teachers, this want in agricultural literature is here supplied in a manner the most complete and satisfactory. They have awarded to it the prize of one hundred dollars, offered for the best treatise of this nature, and it goes out with all the prospect of great and general usefulness which can be hoped for from the high recommendations of its judges, and the reputation of its meritorious author. Nothing more is wanting to satisfy

the clamor of those who doubt the possibility of any good practice coming from books, than such examples as the present, of the union of accurate practical and scientific knowledge in the same volume, set forth in intelligible but untechnical terms, and rich in illustrations drawn from the researches of the laboratory. Few we think are so enthusiastic as to believe that 'Chemistry made easy' will ever teach our farmers the art of chemical analysis; but the day is at hand when it will be no longer safe or reputable for those who cultivate the soil, to be ignorant of the elements of those sciences on which successful practice depends. Such books as the present widely distributed and perused are the surest means of disseminating and fixing these fundamental truths in the practitioners of the "mother of arts."

8. *A Treatise on Algebra, for the use of Schools and Colleges;* by S. CHASE, Prof. Math. Dartmouth College. 336 pp. 12mo. New York, 1849; D. Appleton & Co.—This text-book for the study of Algebra is convenient in size, clear, concise and rigorous in style, and well fitted for instruction. The author states that he has brought out prominently the expressions and formulas required in the higher applications of algebra, in order to render them familiar and easy of use. The work is therefore well adapted to carry the student forward in his mathematical course and prepare him for the reasonings and investigations of Trigonometry, Analytical Geometry, mechanics, and other branches of mathematical study. The convenience of the student is still further promoted by a tabular view of the principal algebraic formulæ.

9. *Minerals and their uses, in a Series of Letters to a Lady;* by J. R. JACKSON, F.R.S., London. 1849. 12mo, pp. 464. Jno. Parker. —As its title implies, this is a work designed especially for the ladies. The author has with considerable skill and some small talk grouped under the several species such facts as are most interesting to the lady reader.

10. *Third Annual Report of the Regents of the University, of the Condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto,* (made to the Senate of the State of New York, January 11, 1850,) Albany, 1850. 176 pp. 8vo, with numerous plates.—This Report consists of a Catalogue of the specimens in the different departments of Natural History, and that of Indian Antiquities, added to the collections from Jan. 1, 1849, to Jan. 1, 1850. Many of the various Indian curiosities, some of which are of singular interest, are figured and described, and they are followed by a notice of several ancient remains of art in Jefferson and St. Lawrence counties, by F. B. Hough, M.D., illustrated by sketches.

Under the Mineralogical Report, by L. C. Beck, M.D., additional information is given with regard to the minerals and mineral springs of the state, partly from other publications, and partly from original observation. A mineral resembling hypersthene from Orange county, N. Y., afforded Beck on analysis, silica 59·50, oxyd of iron 12·00, magnesia 27·75. This composition, if we take the iron in the mineral as protoxyd, gives for the oxygen of the protoxyds and silica 13·32 : 30·92, which is very near 4 : 9, the ratio in hornblende, whence the formula $(\dot{M}g, \dot{F}e)_4\ddot{S}i_3$.* A greenish compact asbestus (rockwood) from Staten

* See Dana's Mineralogy, 1850, p. 685.

Island, gave Silica 55·20, magnesia 30·73, oxyd of iron 11·82, water 2·25=100. Taking the iron as protoxyd in the mineral, the analysis gives for the oxygen of the protoxyds and silica 14·44 : 28·68, or 1 : 2, the ratio in pyroxene, and leading to the formula $(\dot{M}g, \dot{F}e)_3 \ddot{S}i_2$.*

Following the Mineralogical Report there is a catalogue of plants; and then an account of some new species of fossils, and observations on others, by James Hall, with lithographic illustrations. The species remarked upon are named Buthotrephis cæspitosa, Retepora [?] fenestrata, Ægilops (new genus) subcarinata, Murchisonia subfusiformis, Subulites abbreviata, Oncoceras constrictum, Ormoceras remotiseptum, Endoceras lativentrum, Colpoceras virgatum, and Asaphus extans.

11. *Zoology of the Voyage of H. M. S. Samarang under the Command of Capt. Sir Edward Belcher, during the years* 1843–1846. *Crustacea*, parts I and II; by Arthur Adams, F.L.S., and Adam White, F.L.S., 66 pp. 4to, with 13 plates.—The numerous species described and figured in this very important work belong almost exclusively to the order Decapoda. The authors have proposed several new genera, brief notices of which have been before published by them in the Proceedings of the Zoological Society of London. The number of new species here proposed is seventy-nine. The plates are excellent and in part colored.

12. *Hunt's Merchant's Magazine and Commercial Review;* conducted by Freeman Hunt. In monthly numbers of 128 pp., 8vo, New York. —This monthly is one of the Scientific Journals of the country, although the title may not indicate it, and sustains a high character. Its articles are elaborate, and embrace the subjects of Commerce, the Arts and Manufactures, Mercantile law, Insurance, Currency, and related topics: and in each volume a fund of information is collected together, in which every member of society is interested, that cannot be elsewhere obtained in so convenient or full a manner.

13. *Astronomical Journal, Cambridge*, No. 7, April 20, 1850. Observations of Astræa; made with the Filar-micrometer of the Washington Equatorial; *James Ferguson.*—On the recent telegraph operations of the U. S. Coast Survey; *Sears C. Walker.*—Note from *J. S. Hubbard* on *Encke's* comet.—No. 8, May 7. On the orbit of the great comet of 1843; *J. S. Hubbard.*—On an error in the Greenwich planetary reductions; *Ernst Schubert.*—On the Longitude of Hudson (Ohio) Observatory; *Elias Loomis.*—No. 9, May 27th. On the Longitude of Hudson (Ohio) Observatory; *Elias Loomis.*—On a machine for the mechanical calculation of occultations; *Rev. Thos. Hill.*—Elements of Iris; *Ernst Schubert.*—Note on the Longitude and Latitude of Washington, D. C.; *James Carley.*—Supplementary note on an error in the Greenwich planetary reductions; *Ernst Schubert.*—Ephemeris of Neptune; *S. C. Walker.* —Lamont's observations of Neptune.—Comet of May 1st, 1850.—No. 10, June 10th. Ephemeris of Neptune, 1850; *S. C. Walker.*—Observations of Astræa and Hygea; *James Ferguson.* From letters of Prof. Schumacher, to the editor.—Observations of Petersen's comet made at the Cambridge Observatory; *W. C. Bond.*—Southern comet of November, 1849. Letter from Prof. Maury to the editor, with Fer-

* Dana's Mineralogy, 1850, p. 692.

guson's further observations on Petersen's comet.—On the fifth comet of 1847; *B. A. Gould, Jr.*

14. *Scientific Annual.*—A second edition of this volume with some emendations and additions has been prepared and issued. It is gratifying to know that the work has met with so large a sale, and will be continued in future years.

15. *Iconographic Encyclopædia;* by G. Heck, translated by Prof. S. F. Baird,—published by R. Garrigue, New York.—Part 9 of this work has just appeared, containing geographical plates Nos. 23 to 42, and text, pages 641–649 vol. i, and vol. ii, pages 1 to 80.

Lt. M. F. Maury: Notice to Mariners; (second edition,) being sailing directions for the new route to Rio, with tabular comparisons of voyages by the old and new routes. *Washington*, 1850.

Dr. Benjamin Apthorp Gould, Jr.: Report to the Smithsonian Institution on the history of the discovery of Neptune. 8vo, pp. 56. Published by the Smithsonian Institution.

James Higgins, M.D.: Report as State Agricultural Chemist, to the House of Delegates of Maryland. *Annapolis.* 1850. pp. 90.

Lovell Reeve: Conchologia Iconica, or figures and descriptions of the shells of molluscous animals. 4to, parts 1–85, also in separate monographs. *London.* 1850.

—— ——: Conchologia Systematica; or a complete System of Genera, illustrated with 300 plates and over 1500 figures of species. 2 vols. 4to. *London.* Colored 10*l.*, plain 6*l.*

—— ——: Elements of Conchology, an introduction to the natural history of shells—parts i to x. 3*s.* 6*d.* each.

—— ——: The Conchologist's Nomenclator: or Catalogue of recent species of Shells, &c. 21*s.*

—— ——: associated with Arthur Adams, F.L.S. Mollusca of the Voyage of H. M. S. Samarang. Part II, published May 1.

Robert Hunt: Panthea, the Spirit of Nature. 8vo. *London.* 1850.

—— ——: Poetry of Science (second edition): or Studies of the Physical Phenomena of Nature. 8vo. *London.* 1849.

Rev. David Landsborough: Popular History of British Sea-weeds. 16mo. *London.* 20 colored plates. 10*s.* 6*d.*

John Ralfs: The British Desmidieæ; or fresh water Algæ. 1 vol. royal octavo. 35 plates, colored. 36*s.*

Reichenbach: Researches on Magnetism and the other imponderables in their effects on the living frame. Translated and edited by Dr. Gregory. 1 vol. 8vo. *London*, May, 1850.

Arthur Henfrey: Reports and Papers on Botany, 514 pp. 8vo, with 3 plates; published by the Ray Society, London, 1849.—This volume contains, 1, Mohl on the Structure of the Palm-Stem; 2, Nägeli on Vegetable Cells; 3, Nägeli on the utricular structure in the contents of cells; 4, Link's Report on Physiological Botany for 1844-45; 5, Grisebach's Report on Geographical Botany for 1844; 6, Grisebach's Report on Geographical and Systematic Botany for 1845.

Proceedings of the Acad. Nat. Sci., Philadelphia, vol. v. No. ii. March, April, 1850.—p. 22. Catalogue of Crustacea in the Cabinet of the Academy, with critical notes, by *Prof. L. R. Gibbes*, and a committee of the Society, (whole number of genera in the collection, seventy-eight, and of species, one hundred and seventy-five.) —p. 30. Continuation, on the size of the brain in man; *S. G. Morton.*—p. 32. Observation on crystalline bodies in animal tissues; *J. Leidy.*—p. 34. On new American species of Annelida abranchiata; *J. Leidy*, (article to be published in the Journal of the Academy.)—p. 35. Descriptions of new Entophyta growing within animals; *J. Leidy.*

Proceedings of the Boston Soc. Nat. History. November and December, 1849.—p. 193. New shells from Africa (Vaginulus 1 species, Succinea 2, Helix 3, Bulimus 2, Achatina 3, Amnicola 1, Ampullaria 1, Trichotropis 1, Aplysia 1); *A. A. Gould.*—p. 199. Observation on Lepidoptera; *Agassiz.*—p. 200. On the probable origin of certain fossil rain drops; *Whitney* and *Desor.*—p. 203. Observations on the foot of a species of Moschus; *J. Wyman.*—On the circulation and digestion in

the lower animals; *Agassiz.*—p. 206. On the Land dunes of Lake Superior; *Desor.* May, 1850, pages 209–224.—On a young Mastodon; *J. Warren.*—Point of resemblance between Mastodon and Manatee; *L. Agassiz.*—Survey of government Lands on Lake Superior; *J. D. Whitney.*—Skulls of four Hindoo Castes; *Dr. Kneeland.*—Shells of U. S. Exploring Expedition; *A. A. Gould.* Books received ending Dec. 31. Calamite, of Bridgewater, Salt of Great Salt Lake and Carbonate of Soda from "Salæratus Lake;" *C. T. Jackson.* Tin in graphite slates of Vermont; *C. T. Jackson.*

Annales des Sciences Naturelles. MAY, 1849. Researches on Coral Zoophytes, continuation of the very elaborate memoir of *Milne Edwards* and *J. Haime.*—Organization and development of the Linguatulæ, and description of a new species; *P. J. Van Beneden.*—Report on a memoir by Dr. Weddell, on the Natural History of the Quinquinas; *A. de Jussieu.*—Rectification of the Review of the genus Cinchona, published in vol. x, p. 5; *A. Weddell.*—17th notice of the Cryptogamous plants recently discovered in France; *J. B. H. J. Desmazières.*—Chronological exposition of the periods of vegetation, and of the different Floras which have existed successively on the earth's surface; *Ad. Brongniart.*—JUNE. On the Linguatulæ, continued; *Van Beneden.*—On the formation and structure of muscular fibre; *Dr. Lebert.*—Periods of vegetation and floras of the earth, continued; *Ad. Brongniart.*—17th notice of the Cryptogamia of France, continued; *Desmazières.*—New researches into the anatomy and physiology of the Fig tree and Caprificus; *G. Gasparrini.*—Growth of the embryo of Phanerogamia, a series of microscopic researches; *W. Hofmeister.*—JULY. New observations on the Diatomaceæ; *G. H. K. Thwaites.*—On vegetable Embryogeny; *L. R. Tulasne.*—On the organization of the Helminthidæ; *E. Blanchard.*—AUGUST. On vegetable Embryogeny, continued; *L. R. Tulasne.*—On Annelida, continued; *E. Blanchard.*—On the Osteology of the fish called Triodon macroptera; *C. Dareste.*—On a new genus of Brachiopoda, (Davidsonia,) forming a connecting link between the articulated and non-articulated species; *M. Bouchard-Chanteraux.*—Researches on Coral Zoophytes; *M. Edwards and J. Haime.*

Archiv für Naturgeschichte, W. F. Erichson.—*Berlin.*—No. III, 1848. On the Egg of Snails, continued; *H. Rathke.*—On the Echinorhynchus Tuba; *Dr. Creplin.*—Description of a new species of Ascaris, found in the Python bivittatus; *A. Retzius.*—Anatomy and Natural History of Angiostoma limacis; *Dr. Fr. Will.*—Description of small species of Mammalia from Syria and Africa, Genera Rhinolophus, Myoxus, Meriones, Hypudæus, Mus; *A. Wagner.*—On the Gregarinæ; *A. von Frantzius.*—Continuation of the Report on Insects, Arachnida and Crustacea for the year 1847; *Erichson*, (unfinished in consequence of the death of Erichson, and to be completed with the Report for 1848).—Report on Mammalia for 1847; *A. Wagner* of Munich.—No. IV. On the Gregarinæ, continued; *A. von Frantzius.*—Ornithological Fauna of the Faroe Islands, from Kröyer's Tidsskrift; *P. Alberg Holm.*—Report on Mammalia for 1847; *A. Wagner.*—Report on systematic Botany for 1846; *A. Grisebach.*

No. I, 1849. Edited by Dr. F. H. Troschel, Professor at the Friederich-Wilhelms-Universität at Bonn, in connection with Prof. Dr. Grisebach of Göttingen, Prof. Dr. Siebold of Freiburg, Prof. A. Wagner of Munich, and Dr. Leuckart of Göttingen.—15th year. Part I. 1849.—On Boring Mollusca; *A. Hancock.* (From Mag. Nat. Hist., ii, 225, 1848). On the propagation of the Kangaroo; *Dr. Leisering.*—On the bony structure of the Sea Bear and sea Otter; *A. Wagner.*—Third appendix to Gurlt's memoir on the Endozoa of animals; *Dr. Creplin.*—On the anatomy of the Ornithorhynchus and Tachyglossus; *Prof. Mayer* of Bonn.—On the development of Infusoria; *Dr. F. Stein.*—No. II. Development of Infusoria, continued; *Dr. F. Stein.*—Fauna of Iceland, (1st part, Worms); *Dr. R. Leuckart.*—On the shells of the Muscle and Pearls, and their crystallographic and mineralogical relations to calc spar and arragonite; *J. Nöggerath.*—On the mouth parts of the Helicinæ; *Dr. Troschel.*—A word on the quinary System; *J. Kaup.*—On the Boring Mollusca, (continued); *A. Hancock.*—Report on Mammalia for 1848; *A. Wagner.*

Journal of the Indian Archipelago and Eastern Asia, vol. viii, No. 1, 1849.—p. 65. A contribution to the knowledge of the Ichthyological Fauna of Celebes, by Dr. Bleeker. [Contains a catalogue of species, and description of several that are new.]

Soon to appear, published by Gould, Kendall and Lincoln, of Boston, *Hugh Miller's* Footprints of the Creator, with a memoir of the author, by Prof. Agassiz, and also, *Hunt's* Poetry of Science, both works of great merit and interest.

APPENDIX.

*Report on the Experience of the Coast Survey in regard to Telegraph Operations, for determination of Longitude, &c.**

[Extracted from the Proceedings of the Am. Association for the Advancement of Science, 1849, p. 182.]

Mr. SEARS C. WALKER, Assistant in the United States Coast Survey, by instructions from the Superintendent, communicated the substance of his recent Report on the Experience of the Coast Survey, in regard to telegraph operations, as follows:—

The duty of communicating to the Association the experience of the United States Coast Survey, in regard to telegraph operations, has been assigned me by the Superintendent.

The first mention of the electro-magnetic telegraph, in connection with longitude operations, as far as I know, was made, in 1837, by M. Arago to Dr. Morse.

The first practical application of the method was by Captain Wilkes, in 1844, between Washington and Baltimore. Two chronometers, previously rated by astronomical observations in the vicinity, were brought to the two telegraph offices, and were compared together through the medium of the ear, without coincidence of beats. This process is accurate enough for geographical or nautical purposes; but its precision stops short of the mark where the requirements of geodesy begin. In fact, two clocks beating the same kind of time, when placed side by side, cannot be compared together, by the human ear, with sufficient precision for geodetical purposes. The subsequent experience of the

* This article should have appeared in this Journal, at an earlier day; but the very tardy issuing of the volume of 'Proceedings,' &c., in which it is printed, prevented our publishing it at the same time with the article on the 'Electro-chronograph' by John Locke, which appeared in September last year, (vol. viii, p. 231.)

It is well known that a personal controversy exists among claimants in this interesting research. It is not our purpose to discuss its merits, did we understand them. The responsibility of published statements must rest with those who make them, and we wish it distinctly understood (as we suppose indeed it now is), that the Editors of this Journal hold themselves responsible for no facts or opinions published in these pages, unless uttered in their own individual or collective names. No articles find admission to our pages without the name of a responsible author, and beyond the strict limits of improper personality, the authors alone are to be held responsible for the ground assumed in their several communications.

A long experience has convinced us that there is no ground, except that announced above, on which we can safely stand, in cases where controversy exists in matters of science.—*Editors Am. Jour. Sci.*

Coast Survey has shown, that where several astronomers make independent comparisons of clocks, in this manner, two seconds of arc, or twelve-hundredths of a second of time, is an average discrepancy between their results.

The subject of telegraph operations for longitude had engaged the attention of the Superintendent of the Coast Survey, previous to the experiment of Captain Wilkes; but the orders received by me for this purpose, bear date of November 24, 1845. In 1846, the very first season in which two astronomical stations of the Survey were brought in connection by the Morse telegraph lines, the work of connecting them together, in longitude, was commenced in earnest by the Superintendent of the Coast Survey. The coöperation of the National Observatory, as one of the stations, was freely tendered by its Superintendent, Lieut. Matthew F. Maury, U. S. N., and accepted by Prof. Bache. The detail of the operations was left to me. The Comptrollers of the Public Schools of Philadelphia had tendered the free use of their High School Observatory, under the direction of Prof. E. Otis Kendall. An additional station, at Jersey City, was fitted up by the Coast Survey, with astronomical instruments, under the direction of Prof. E. Loomis. The three stations were connected by special junction lines, (built at the expense of the Survey,) with the main Morse line, from Washington to Jersey City, under the Presidency of the Hon. Amos Kendall. Three full sets of telegraph keys and receiving magnets were made for the purpose, at the machine shop of the Coast Survey Office, under Mr. Saxton's directions, and three Morse registers were purchased for the occasion, from Mr. Clark, an instrument-maker in Philadelphia.

Owing to the imperfect insulation of the lines, the connection of Jersey City with Washington failed that year; but the Washington and Philadelphia stations were connected together astronomically on the 10th and 22d of October.

The method of comparison, by coincidence of beats of solar and sidereal timekeepers, was not introduced this year; but the equivalent one was employed, namely, the exchange of star signals. These are the dates of instants of the passage of a star over the wires of the eye-piece of the transit instrument, signalized by tapping on the telegraph key at one station, and recording it on the Morse register at both.

Since this operation of making the time of a star's transit legible on any number of registers at any number of stations is likely to come into general use, in geodesy, geography, and hydrography, so long as there remains on the earth's surface any two important points whose relative longitude is unknown, the origin of the method must be a subject of historical interest.

The idea of substituting for clock signals, which have no immediate relation to longitudes, those of the times of a star's tran-

sits, which have such a relation, occurred in the winter of 1845 and 1846, in a consultation between the Superintendent and myself. Which made the first suggestion, I cannot now say, nor is it a matter of much importance to either of us personally. As respects the service in which we are engaged, the origin is a matter of importance. It is a subject of just pride to those engaged in it, that the first conception of the method, and the first practical operation with it, are peculiarly its own. The blank form, No. 2, of telegraph operations, drawn up by me in the spring of 1846, and lithographed for use at the three stations, is headed "Coast Survey," and is described in my lithographed "Circular to the Telegraph Operators." It is dated "Coast Survey Office, September 25th, 1846." In pursuance of this programme, on the 10th of October, the transit of the star 2838 Bailey, over the seven wires of the west transit instrument of the Washington Observatory, was signalized by Lieut. Almy, U. S. N., the officer having charge of that instrument. This transit was noted on the Washington clock, by Lieut. Almy, and also by myself, comparing together, by the ear, the seven key beats, with the clock beats. The same key beats were also noted by Prof. Kendall, at Philadelphia. This was the first practical application of the method of star signals, which is sooner or later to perfect the geography of the globe. The signals were made visible on the running fillet of paper. The fillet was not then furnished with a visible graduation.

The *personal graduated clock register*, and the *personal register of the star signal*, were both made in an evanescent form on the *auditory nerve* of the ear. Two years later, (1848,) the *visible* was substituted for the *auditory* register, in the month of July. In the month of November, the *automatic visible register* took the place of the *personal visible register*, and constituted the last step in the improvement of the art of telegraph operations for longitude.

Whether we use the *personal auditory*, *personal visible*, or the *automatic visible* register, the theory of the resulting longitudes is the same. They differ only in the superior facility, precision, and permanency of the latter.

This analytical theory, from beginning to end, belongs to the Coast Survey Service. My letter to the Superintendent, on file in the Coast Survey Office, dated October 3d, 1846, contains the *analytical theory* of longitudes by star signals, whether recorded on a *personal auditory register*, as in 1846, a *personal visible register*, as in 1848, or an *automatic visible register*, as in 1849.

I deem it, therefore, but a duty to the service in which I am engaged, to declare, in the presence of the members of the Association, that, with the single exception of the experiment between Baltimore and Washington, by Captain Wilkes, in 1844, I

know of no telegraph operations for longitude, and of no step in the improvement, or perfectionment of the art in Europe or America, which have not been the work of the officers proper of the Coast Survey, or of commissioned officers and civilians acting temporarily as assistants.

After this digression, I resume the recital of our experience in the Coast Survey.

In 1846, we connected together, in longitude, the Washington and Philadelphia stations. In 1847, the programme left unfinished in 1846, by the imperfection of the lines, was resumed and completed, and Washington, Philadelphia, and Jersey City, were connected together. On the 27th of July, 1847, the method of coincidence of beats, used so successfully by R. T. Paine, Esq., in the chronometric operations for longitude, in Massachusetts, and by Struve and Airy in their chronometric enterprises, was applied to the telegraphic comparisons of the Philadelphia and Jersey City Clocks. This method of coincidences was used in combination with exchanges of star signals in the telegraphic operations of the Coast Survey, in 1848, when the Cambridge Observatory, under Prof. Bond, and the Stuyvesant station in the garden of Dr. Rutherford, New York, under the direction of Prof. Loomis, were connected together by the Coast Survey. The lines of junction with the main line, under the presidency of the Hon. Francis O. J. Smith, the telegraph apparatus, and the astronomical instruments of the Stuyvesant station, were furnished at the expense of the Survey. During these operations, in July and August, Prof. Bond proposed to substitute the *automatic* instead of the *personal seconds circuit breaker*, and submitted to me a sketch of his plan for effecting the *make* and *break* circuit by the escapement beat. On my special recommendation, by report to the Superintendent, dated August 11th, 1848, an order was given to Mr. Bond for the completion of a *circuit breaker clock* on his plan.

The *automatic clock circuit breaker*, named by Dr. Page, of Washington city, an *electrotome clock*, is not an American invention. It was used more than ten years ago, by Messrs. Wheatstone, Bain, and Steinheil, in Europe. It is due also to Prof. Bache, Mr. Saxton, and Dr. Morse, to say that each of them suggested the use of *clock electrotomes*, in 1846, with particular descriptions of the methods. I was deterred from using them in connection with the observing astronomical clocks at the time, from apprehension of disturbance of their rates.

This apprehension was in reality groundless, and I would here make the remark that all the methods then and since proposed or tried, for *clock electrotomes*, and all the various methods of registering, are precise enough for the purposes of geodesy. Hence, in giving preference to one over another, we should only be guided by considerations of facility and economy of outfit, and of facility of making, reading, and preserving the printed registers.

After concluding the work between Cambridge and New York, in 1848, the month of October was employed by the Coast Survey in connecting Philadelphia and Cincinnati, by means of the O'Reilly Morse lines. The Philadelphia junction line was made by the Coast Survey. The Cincinnati junction line of half a mile in length was erected by Henry O'Reilly, Esq., and presented to the Cincinnati Observatory, as his subscription towards that establishment. The transit and telegraph instruments for Cincinnati, were supplied by the Coast Survey for Prof. Mitchel.

The labors of the year 1848 comprise some 1800 observed transits of stars, 800 comparisons of chronometers, by coincidences of beats taken at the stations, 5,000 transits over wires, for determining the personal equations of the officers of the Survey, many thousand exchanges of personal clock signals, and 600 of star transit signals.

If even this prodigious accumulation of statistics was considered a gain of many fold over the old method of obtaining astronomical longitudes, what shall we say of the automatic process employed in 1849, where one night's exchange of star-signals between Philadelphia and the Seaton station, printed automatically on the single sheet of paper now before you, is worth the whole list of statistics collected by the Coast Survey between Philadelphia and Washington, in 1847.

The subject of the invention of the automatic clock register is explained in full in my Report to the Superintendent of the Coast Survey, of December 15th, 1848, which, with his letter communicating it to the Treasury Department, and that of the Hon. Robert J. Walker, communicating both to Congress, have since been extensively circulated by the press.

I will not here allude to the respective claims of Americans for priority or superior excellence of inventions and suggestions, believing that it will be becoming for all of us, to look to the great work that has been accomplished, by our united efforts, rather than to the single share of each.

Feeling the responsibility under which I was acting, I spoke with caution on the subject of the comparative excellence of the automatic printing method; though some of my friends thought that its merits were overrated. I appealed to the experiments that were to be made in the campaigns of 1849 for a test of the new method. That which was then anticipation only, is now reality; and I am able to say, from recent trials, between Cambridge and Washington in January last, and between the Seaton station under my care at Washington, and the stations at Philadelphia under Prof. Kendall, and Hudson, Ohio, under Professor Loomis, in July and the current month, that the excellence of the new method surpasses all that I ventured to hope for in December last. I then ventured to claim for the automatic printing

method a ten-fold gain over the old one. I now find that one transit over one wire is worth four wires by the old method, and that ten transits over wires may now be printed, where one was done before; making a gain by the new or automatic method of some forty-fold. I mean by this the gain from multiplication of transits over wires, and superior precision of each. We cannot in one night obtain the advantage of the average of the meteorological peculiarities of forty.

The various clock *electrotomes* may be thus classified:

Author.	Date of invention or suggestion.	Description of method.
Wheatstone . .	1840.	Circular disc on arbor of second's wheel.
Bain	"	Sliding rod moved by pendulum.
Steinheil . . .	Not known.	
Saxton . . .	At launch of Frigate Raritan.	Platinum tilt hammer moved by pendulum.
Saxton . . .	In 1846.	Globule of quicksilver struck by pendulum.
Johnson & Speed .	In 1847.	Platinum tilt hammer struck by teeth of the minute wheel.
Bond	In 1848.	Escapement electrotome.
Mitchel . . .	"	Quicksilver struck by pendulum.
Locke . . .	"	Platinum tilt hammer struck by teeth of seconds-wheel.

I have already remarked that I believe that all these electrotomes will succeed in practice, without injury to the rate of the clock. In making our selection we must look to facility and cheapness of construction, and to uniformity of graduation of the time scale. In the present state of my experience on this subject, I prefer the form now in use at the Seaton station, recently applied by Mr. Saxton to the Hardy dead-beat clock of the United States Coast Survey, imported by its late Superintendent, Mr. Hassler, and by him described in the Transactions of the American Philosophical Society. The electrotome is on the model used by Mr. Saxton several years ago, at the time of the launch of the frigate Raritan, at Philadelphia. The perfect gravity escapement, (resembling, I believe, that which was recently invented by Dr. Locke,) has been substituted by Mr. Saxton for Hardy's springs. Two pounds have been added to the weight of the clock to prevent danger of stopping by increased friction. In this condition Mr. Saxton expresses the opinion that the clock of the Seaton station is the best clock extant. It has broken the circuit for forty days without interruption, and has in no instance deviated in an appreciable amount from its losing rate of one-tenth of a second per day. For a more full understanding of it, I refer you to the accompanying description and drawings by Mr. Saxton.

I have spoken of the *automatic circuit breaking clocks;* it remains to notice the *automatic registers.* The first in order is the registering fillet of Dr. Morse, described in my report of Decem-

ber last. This has no maintaining power. It may be made to run with one winding for fifteen minutes; but gives uncertain records during the time of winding.

In reading off the dates of the signal electrotomes on the clock electrotome scale, a small strip of paper or of horn, is used, which in ten inches diverges from a point to the extent of a second on the register. This is placed on the fillet of paper, so that its width equals the distance of the clock and signal electrotomes. The tenths of seconds are read off at sight, and hundredths are set down by estimation. A correction for rate of the actual time scale on that of the normal or measuring scale might be applied if we wished; but on experience of a month at the station, we find that the neglect of it brings an error not greater than that of the conjecture, relative to the hundredth of the second, so that in practice we may dispense with the correction altogether.

The next method is the *chemical* method of registering with the main circuit. I have made full experiments with it, and think that the advantage of avoiding the errors of the relay and primary armature time, are more than counterbalanced by the difficulty and irregularity of the action of the current, the indistinctness of the edges of the scale pauses after the paper is dry, and the irregularity of hygrometric expansion of the paper.

In the experiment of measuring the velocity of the hydro-galvanic current, the method will be useful, as it removes all questions relative to *armature* time, though perhaps it substitutes a longer delay, which I may call *chemical action* time.

On the subject of the velocity of the hydro-galvanic current, I would remark that the experiment of January 23d, between Cambridge, Philadelphia, and Washington, indicates a velocity about one-tenth of that of light. This value, though probable, is by no means certain, and I would wish to speak with caution till more experiments are made.

The third form is the register on a disc with concentric circles, as described by Prof. O. M. Mitchel, in his letters to the Superintendent.

Prof. Mitchel's experience of the despatch and precision of the work, confirms my own. I have no doubt that his method of registration is excellent; perhaps not inferior in compactness, precision, and facility of reading off, to the Saxton sheets. I should wish for the opportunity of personal inspection before giving an opinion conclusively on the subject.

The fourth form of the register is Mr. Saxton's invention of this year. I submit his drawings of the machine. It is somewhat on the plan of his celebrated ruling machine. The cylinder now before the Association contains the culmination of the planet Neptune and the stars near his parallel, printed by me at the Seaton station, Aug. 11, 1849. It might seem that the sub-

ject of the place of the planet Neptune is foreign to the purpose of telegraph operations. Such is not the case; for we have used this planet as a fundamental star. I take occasion, therefore, to remark that the observations of the culmination of Neptune on four nights in the month of August at the Seaton station, by Pourtalès and myself, show that my Ephemeris, published by Prof. Henry in the Smithsonian Contributions to Science, agrees with the heavens within half a second of arc. From this close agreement it may be inferred that if the Neptune of Prof. Peirce's theory and my elements were conceived to be a planet, placed side by side in the heavens with the true one ever since its discovery, the two would form a double star of an order so close that not even the great Cambridge refractor could detect their duplicity.

An objection has been urged to the Morse registering fillet, that it is too voluminous for the quantity of matter recorded. This objection and that of expensiveness, occur with more force to the metallic cylinder, however accurate be its indications. To remedy this evil, Mr. Saxton has contrived a sheet of paper which encloses the cylinder and lasts for about two hours of constant work. The sheets and registering fillets now submitted for the inspection of the Association, contain the comparison of the printed record of the culmination of the stars in the Dolphin. The Saxton sheet, the chemical fillet, and the Morse fillet, are triplicate records of the same identical star signals. The result of the reading, as far as experiments have been made, is, that all kinds of registers at the same place read alike. It is worthy of remark that these registers contain the printed record of the transits of both components of the double star Gamma Delphini, printed with ease on each of the forty-five wires of the Wurdeman's diaphragm, making ninety imprints in a culmination.

From my experience in printing the transit of this pair of double stars, I am led to the conclusion, that four stars forming a quadruple star, when at proper distance, may all be printed at the time of their transit over a diaphragm of fifty wires, making two hundred imprints for one transit, a rapidity of playing on the key far below that of good execution on the piano.

The other sheet before you contains the longitude between the Seaton station and Philadelphia. It was registered at Washington. The Morse fillet on the reel now before you is the duplicate Philadelphia register.

This work was performed last Monday night. You will notice a curious occurrence on several occasions that night. Three distinct telegraph operations were going on at once. The Seaton station clock was graduating the time scale for both stations. Two stars differing in right ascension by about the longitude of the places, were in the two telescopes at the same time, and the

imprints of the transits are interspered, without confusion on the register. Since one wire at each station gives the longitude of the places, we can find cases where the work of a single second has effected this purpose better than a year's work could do without the telegraph.

The diaphragms of nine and eleven tallies (45 and 55 wires,) made by Mr. Wurdeman, formerly the Mechanician of the Coast Survey, are so nearly perfect in their structure that the probable error of his locating of any single wire, in reference to a normal location with equal intervals, is only four hundredths of a second of time. This precision is a matter of great importance in the use of a diaphragm of so many lines, whose equatorial interval, unless in the case of known symmetry, would need a special determination.

Of all the different kinds of registers here alluded to, I prefer the sheet of Mr. Saxton. One sheet filled on both sides, or two pages, will contain an ordinary night's work. A year's work will make a book of some three hundred pages, on the margin of which may be entered the ordinary remarks for an observing book, relative to the state of the level and meteorological instruments, name of stars observed, and instrumental deviations.

If folded up, or bound and put away for a century, the reduction of the work will then be as easy as at first.

In fact, we may, with the metallic cylinder, electrotype the plate; or, using copper, we may print from it without. And, in the case of the paper sheet, instead of Saxton's graver, with Indian ink, we may employ a pen, with lithographic ink, and multiply copies at pleasure, whenever we choose. When we consider the compactness of the register on Saxton's sheet, we may perhaps find that the publication of transit observations will best be made by the lithographic process, applied to the printed telegraph sheets; thus giving to the world the printed record with all the accuracy of a daguerreotype. The registering fillet now exhibited to the Association, contains the culmination of both limbs of the moon, printed by myself, on the 3d of August last, on 35 wires of the diaphragm. By mean of the results, the probable error of the imprint of a transit of single limb, over a single wire, is the sixteenth of a second; whereas, in 1846, with the great Washington Equatorial, and a power of 300, I found that, with the old method, my probable error, by 66 trials, was twice as great, namely, the eighth of a second. Thus it appears that the measure of precision is twice, and the weight four times, as great, in the new method, as in the old.

No labor of training for the work is needed. Master Langton, the youngest Assistant at the Seaton station, printed the transits of four stars, on the 18th July, for his first trial. The fourth transit is on the register now before you. On reading off Master

Langton's imprints, we find them as accurate as any of our work, and far more so than that of the most experienced observer by the old method.

A hundred wires is a high estimate for a night's work of an observatory, by the old method. I have printed fifteen hundred wires, without fatigue, in one night, by the new. Since each wire is worth four of those of the old method, we have six thousand to one hundred, or sixty to one, as the relative efficiences of the night's observations.

When we reflect, that the probable error of one transit, over one wire, is only the sixteenth of a second, and that with five wires it is only a thirty-sixth part, or three hundredths of a second, it is manifest that one tally, or five wires, is ample for all ordinary work. In fact, one wire is sufficient for most of the purposes of astronomy. I have been led, on consideration of all the facts known from the experience of the Coast Survey, at the Seaton station, to make the following remark relative to the precision of our work, after proper adjustment of the transit instrument, or measurement of its deviations from a normal state: *The printed transit of a fundamental star over any wire of Wurdeman's diaphragm, and that of a star, planet, or comet, whose place is sought, over another wire—both reduced to the centre, on the supposition of uniformity of interval—give the place of the object sought, with a precision not much below that on which rest the present elements of all the bodies in the solar system.*